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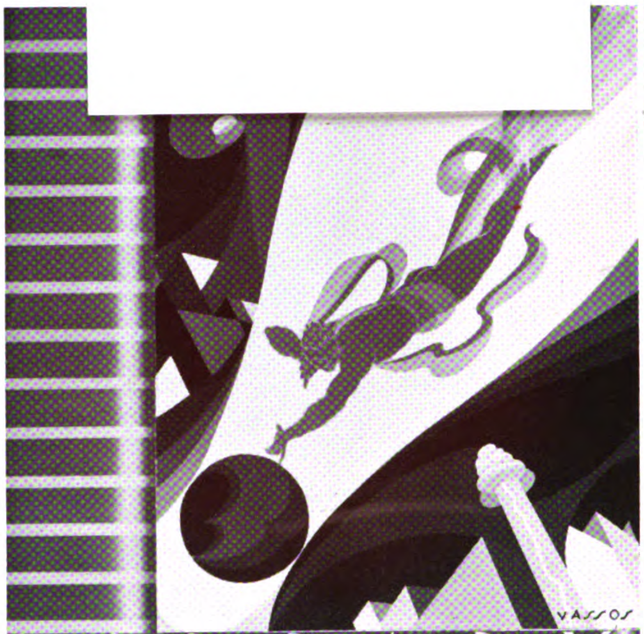

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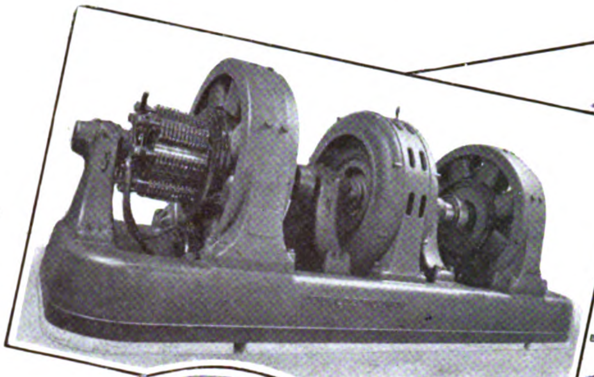
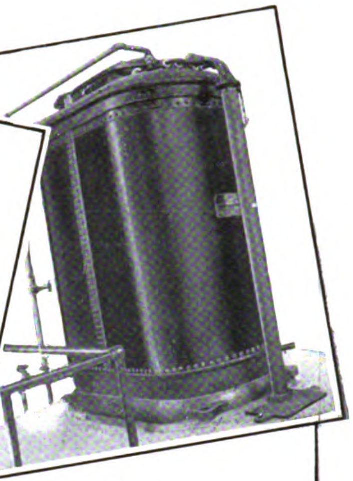
THE DEVELOPMENT AND EXTENSIONS OF THE NIAGARA POWER SYSTEM UP TO DATE.

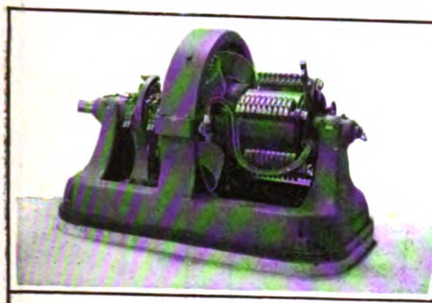
REPLETE WITH INFORMATION ON THE MOST ADVANCED DEVELOPMENTS OF POLYPHASE WORK.

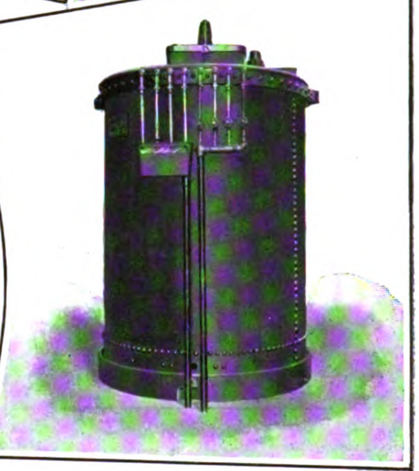
BY J. E. WOODBRIDGE

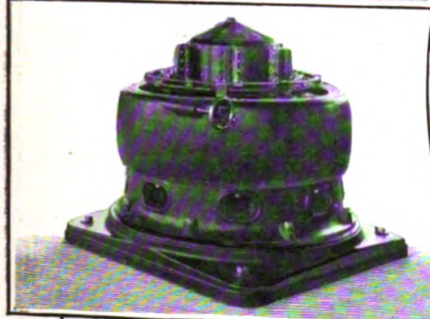
Such a memorable point in the progress of time as the beginning of a new calendar century is certainly an appropriate occasion for a review of the greatest, most original and most elaborate inter-connected system of electrical installations in this country or the world over. This is all the more true since during the past year this system has been greatly enlarged; new generators, lines, transforming devices and loads have been added; one of these loads constitutes by far the largest single application of power in one structure ever made; this with the other additions has nearly doubled the output of the power plant, and the outlook for the future has necessitated the immediate duplication of the generating equipment which already enjoys the unique distinction of being the largest in the world.

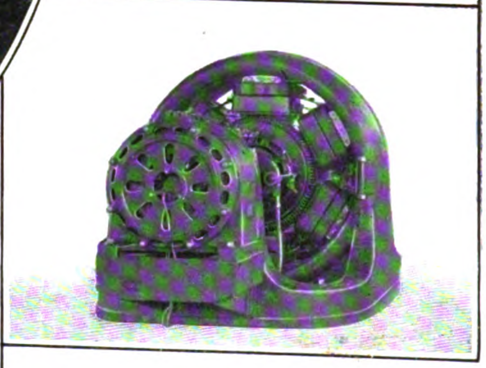


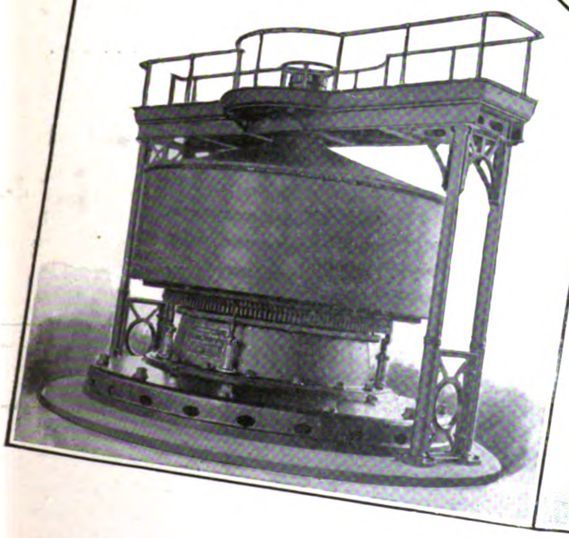


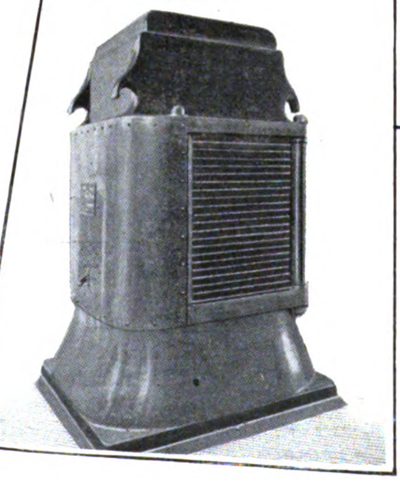


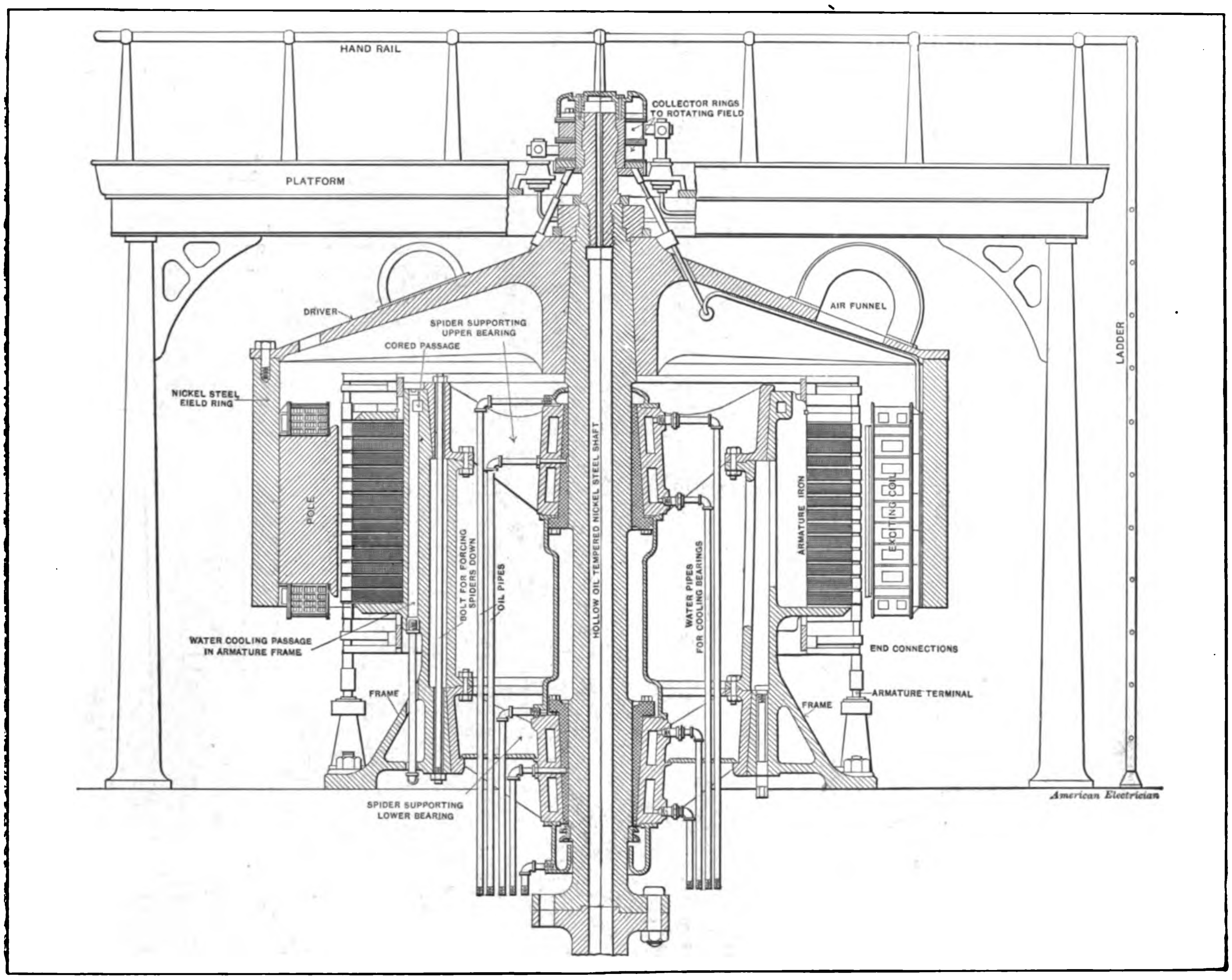








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PLATFORM
DRIVER
SPIDER SUPPORTING UPPER BEARING
CORED PASSAGE
AIR FUNNEL
LADDER
NICKEL STEEL EIELD RING
POLE
BOLT FOR FORCING SPIDERS DOWN
OIL PIPES
HOLLOW OIL TEMPERED NICKEL STEEL SHAFT
WATER PIPES FOR COOLING BEARINGS
ARMATURE IRON
EXCITING COIL
WATER COOLING PASSAGE IN ARMATURE FRAME
END CONNECTIONS
FRAME
ARMATURE TERMINAL
FRAME
SPIDER SUPPORTING LOWER BEARING
American Electrician

FIG. 2.—VERTICAL HALF SECTIONS OF ONE OF THE 5000-H. P. GENERATORS SHOWING THE IMPROVEMENTS OVER THE FIRST FORM. THE LEFT-HAND SECTION SHOWS THE WATER-COOLING PASSAGES IN THE ARMATURE FRAME AND THE OIL PIPING TO THE BEARINGS. THE RIGHT-HAND SECTION SHOWS THE WATER COOLING ARRANGEMENTS OF THE BEARINGS.

It may be well at the start to outline briefly the extensions and additions of the last two years. The generating plant has been increased by the addition of seven 5000-h.p. machines to the original three. Several new local electro-chemical loads have been added at Niagara Falls, the greatest of which is the new works of the Union Carbide Company, which already absorb 15,000 h.p. The long distance transmission of power has been greatly amplified. Twenty-seven miles from the power plant the Buffalo General Electric Company takes 3,000 h.p. and transforms it to four different styles of current for its central station service, the running of the steam stations of this company having been discontinued. The International Traction Company, which operates all the street railroads in Buffalo and the adjacent territory, has installed a rotary converter station in Lockport and four new ones in Buffalo. At Tonawanda a transforming station has been connected up to carry both lighting and traction loads. These various elements of the system that have been recently added are described below in a general way with as many previously unpublished and novel details of construction and operation as available space will permit.

The original plans of the Niagara Power Company contemplated the extension of the present power house until it should contain sixteen generating units with an aggregate nominal output of 80,000 h.p. During the past year two of these units, the ninth and tenth, have been erected and here for probably many years the growth of the present house will stop, although the original intention to extend further is evidenced by the temporary wall at the north end. A contract has already been signed with the National Contracting Company to excavate another wheelpit of sufficient size to accommodate ten more units and before this article is read ground will be broken for this new work. This change of plan is due to the fact that the discharge from wheels developing 100,000 h.p. will fill the existing tail-race tunnel and it is considered preferable to divide this 100,000 h.p. equally between two power houses than to locate 75,000 or 80,000 h.p. in one and only 20,000 or 25,000 in the other. The next subsequent development will, it is expected, be on the Canadian side, where a shorter and consequently less expensive tunnel can be put in. For these reasons the statement is made above that the extension of the original power house has probably ceased for some time to come with the end of the past year.

The new 50,000-h.p. power house will be located on the other side of the entrance canal or forebay from the present building and considerably to the rear towards the river, leaving ample room in front of it for extensions of the transformer house, which already stands on this side of the canal in front of the site of the new structure.

THE NEW GENERATING UNITS.

The two new pairs of turbines with their attached dynamos are almost exact duplicates of the five installed during the previous year. The water wheels themselves differ only in slight details such as the material of which the lower distributors or guide chutes are made. These in the new wheels are of phosphor bronze instead of cast-iron to better resist the chipping action of small stones that may work into the pen-stocks. The turbines are like their immediate predecessors mounted on steel girders instead of cast-iron brackets, as were the original three sets. These, however, have been previously described in the technical press.*

The two new generators are exact duplicates of the previous five, no possible improvements over those machines being found. While the changes embodied in these five as compared with the original three have been previously published they have not been noted in these columns, so that a brief mention of them is warranted here. The general design of outside umbrella type fields rotating about an internal stationary armature remains the same. The changes are only in details and as a rule have been made with the aim of better carrying off the heat generated. Although the machines have an extremely high efficiency, about 98 per cent, the 2 per cent. wasted amounts to 100 h. p., which is considerable to be dissipated from the superficial area of machines concentrated into as small volume as are these.

Fig. 2 shows two vertical half sections through one of the machines, illustrating the two principal improvements over the first designs. One of these is the method of supporting the bearings in accurate concentric alignment with the frame and the other is the cooling arrangement. The spiders holding the two bearings are forced downwardly by means of bolts shown into tapered seats bored in the interior of the frame. The bearings themselves are also forced to a tight fit in the spiders. These bearings are piped to an oil circulating system, as shown in the left-hand section, and chambers cored in them are piped for the circulation of water for cooling purposes, as shown in the right-hand section. The frame itself has vertical ribs in which the armature laminations are dovetailed and through these ribs run vertical passages, as shown in the left-hand section, through which passages water is circulated for the purpose of cooling the iron. Pipes connect the lower ends of these passages while the upper ends are capped and connected together by means of small square cross passages cored in the casting. The connections are such that the water must flow up one passage and down the next, and so on throughout the whole series around the frame. In addition to this there are the usual ventilating spaces in the armature iron through which air is drawn by the centrifugal action of the fields and air funnels mounted on the drivers.

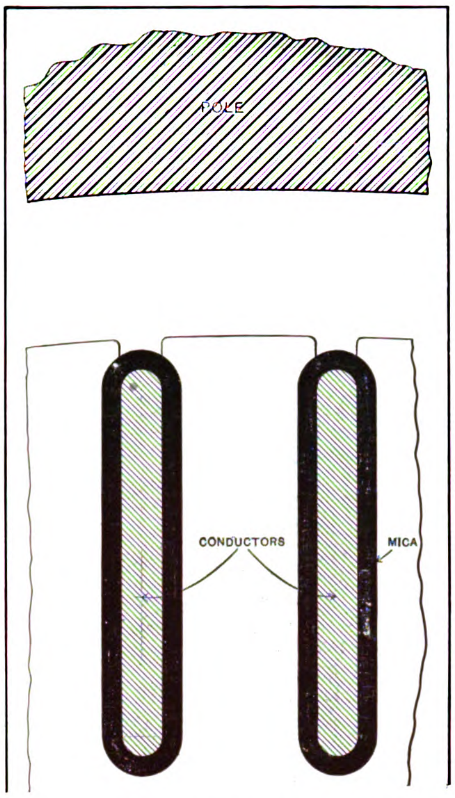

FIG. 3—A FULL-SIZE CROSS SECTION THROUGH TWO ARMATURE SLOTS OF THE NEW NIAGARA GENERATORS.

The field coils are made up of bare copper strap wound edgewise but differ from usual edgewise coils in that there are four layers. Fig. 5 shows a plan and partial

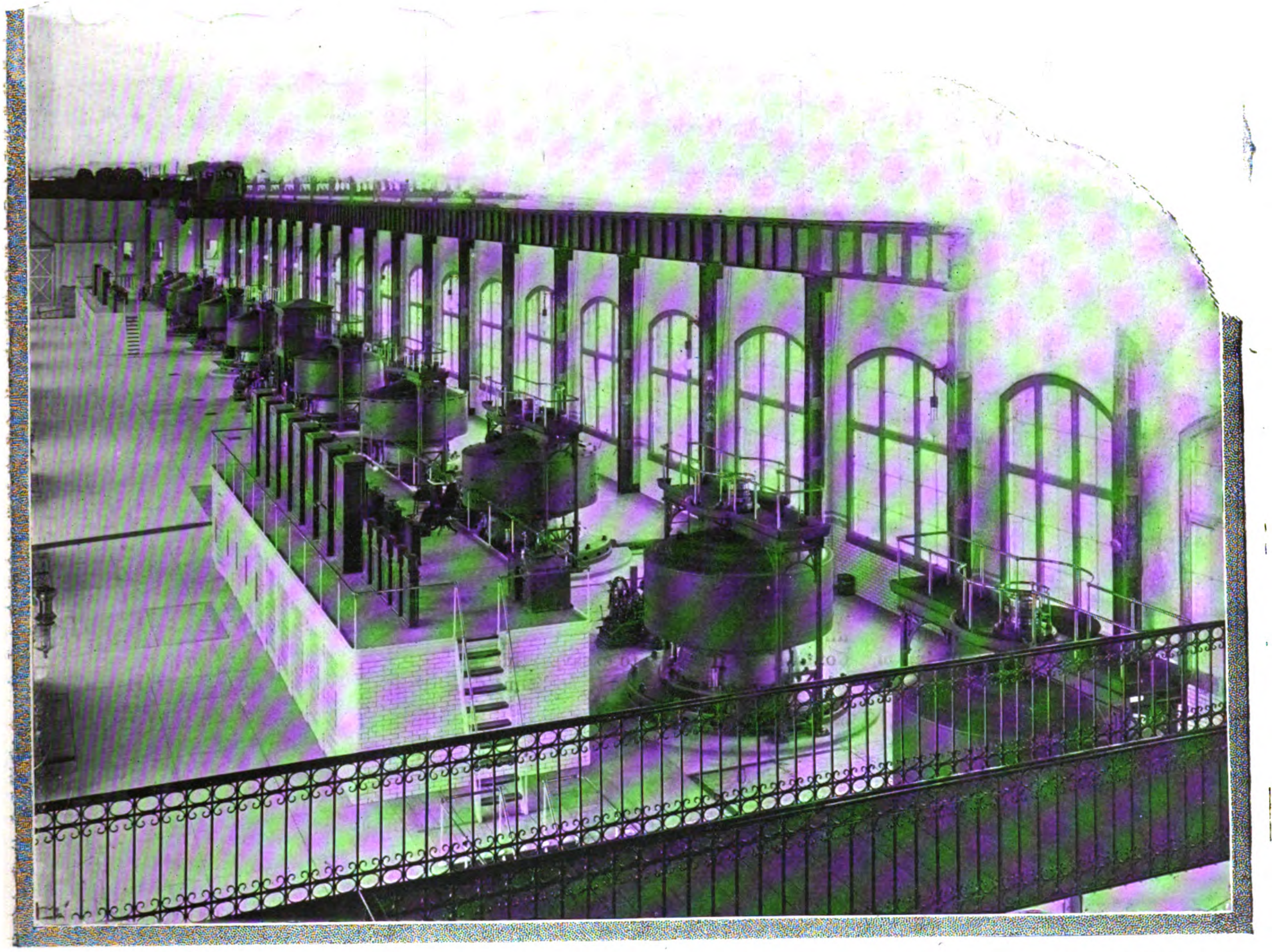

FIG. 4.—TEN DYNAMOS WITH A CAPACITY OF 50,000 HORSE POWER, AT PRESENT THE LARGEST GENERATING PLANT IN THE WORLD.

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*See article by the writer in the Electrical World, Jan. 7, 1899.

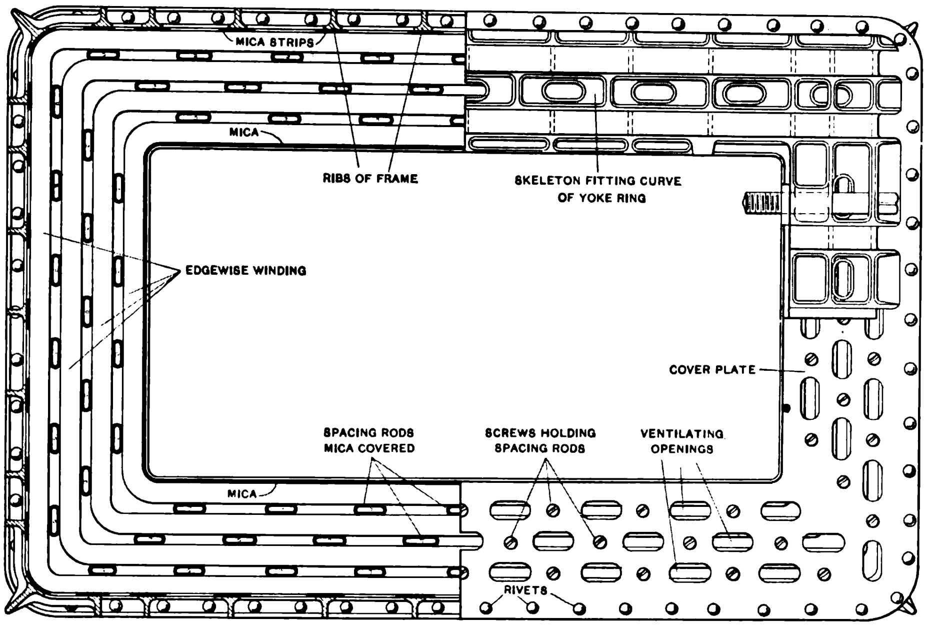


FIG. 5.—THE CONSTRUCTION OF THE FOUR-LAYER EDGEWISE WINDING OF THE FIELD COILS OF THE NEW 5000-H. P. GENERATORS.

section of one coil. The four layers are separated from each other and rigidly held in place by means of metal spacing rods covered with mica and shellac insulation. Between these spacing rods there is ample room for the ventilation of each layer, the circulation of air being permitted by means of ventilating openings in the casing. This casing consists of a brass framework of skeleton ribs and perforated plates riveted together, the spacing rods being fastened to the plates by screws. The edgewise turns of each layer are insulated from each other by strips of built-up mica and shellac insulation inserted between them.

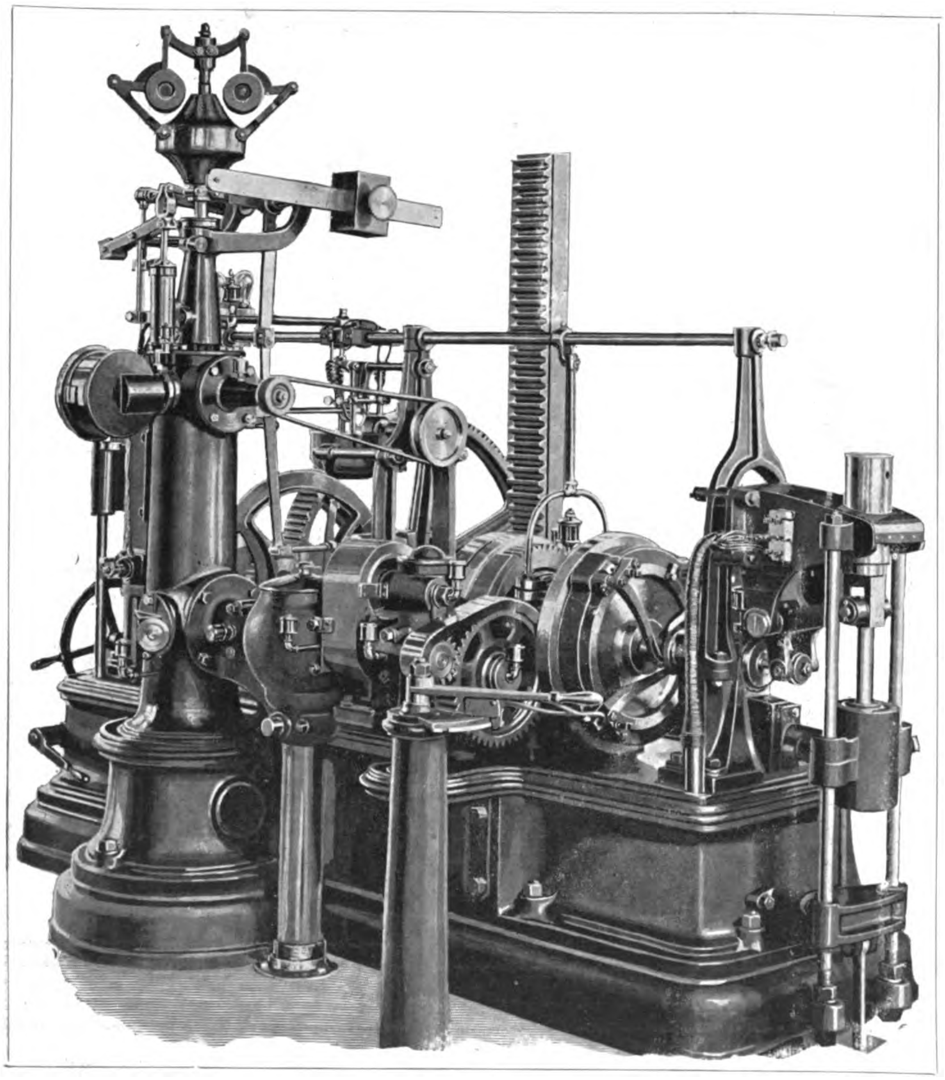
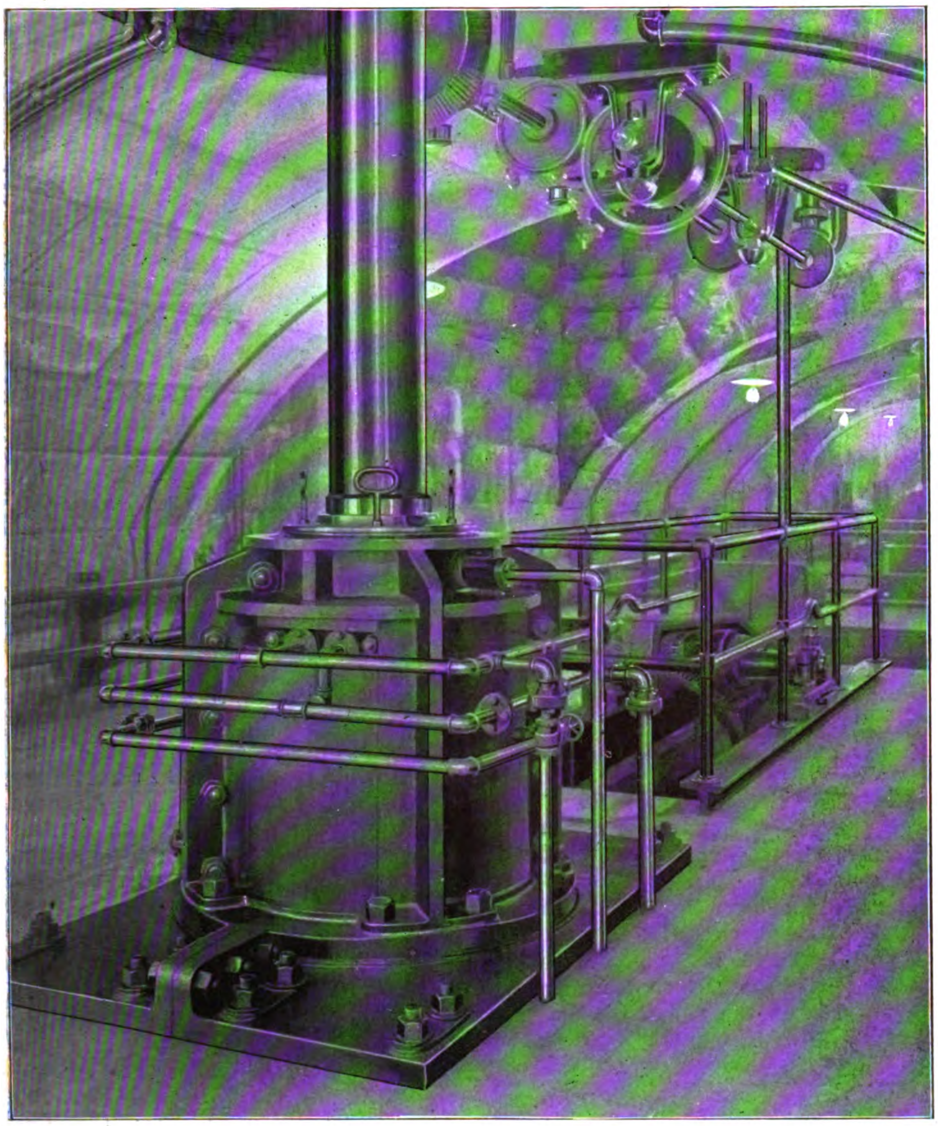


FIG. 6. ONE OF THE NEW GOVERNORS. THE CENTRIFUGAL WEIGHTS OPERATE CONTACTS IN AN OIL BATH, AND THESE CONTACTS CLOSE THE CIRCUITS OF ELECTROMAGNETIC CLUTCHES, ONE FOR THE OPENING AND THE OTHER FOR THE CLOSING MOTION OF THE GATES.

The ten machines are connected in two groups of five each to panels and switch stands on two switchboard galleries laid out on the same general plan as the original gallery for the first three machines. There are two complete sets of two-phase bus bars under each gallery and these sets of bars may be run separately or thrown together by means of bus-junction switches. The two original rotary converters for excitation have been moved to a new location and are maintained, but only as a reserve, the machines being normally excited by any one or more of four turbine-driven direct-current dynamos grouped around the elevator shaft in the center of the room. These dynamos are of a novel type, being mounted on vertical shafts, the armature overhanging the upper bearing. One of them is shown on page 1. These exciters have no governors, the gates of their water wheels being driven by hydraulic apparatus in turn controlled by magnetically operated valves switched on or off at the switchboard.

The new main wheels are controlled by magnetic clutch governors designed by Dr. Coleman Sellers; one of these governors is shown in Fig. 6. The big machines have no circuit breakers, their power being cut off by simply opening the field circuit. The same action starts the governor into motion to shut off the water from the main wheels. The circuit breakers in the field circuits of the machines are wired to an emergency switch by closing which the fields of all the machines running in parallel with each other may be opened simultaneously in case of emergency and the gates of the water wheels of the same units may be at the same instant started toward the closed position.

At the time this article was written, in November, the two new machines were not completed and the eight machines in service were being operated in three batteries carrying a load of from 30,000 to 35,000 h.p. One battery of two machines was necessarily run separately from the others to carry the long distance transmission loads of Tonawanda, Buffalo and Lockport. The isolation of these machines and loads from the others was necessitated by the facts that the drop in the transmission lines required a higher pressure than that delivered to local loads in Niagara Falls, and the distributing system of the station is not equipped with boosting or other voltage varying devices for delivering different pressures from one battery of machines in parallel. Of the other two batteries of three machines each, one battery was running on the mammoth load of 15,000 h.p. absorbed by the new plant of the Union Carbide Company, while the other battery was carrying local loads of the other "tenants," as



IG. 7.—A VIEW ON THE THRUST-BEARING DECK. THE ARCHES SUPPORT THE DYNAMO ROOM FLOOR ABOVE. IN THE FOREGROUND IS ONE OF THE THRUST BEARINGS WITH ITS OIL AND COOLING WATER PIPES. BEYOND IS ONE OF THE COUNTERWEIGHTED BEAMS OF THE GATE-MOVING MECHANISM AND ABOVE IS THE GEARING BY WHICH MOTION IS TRANSMITTED FROM THE SHAFT TO THE GOVERNOR.

they are called, consisting of electrochemical and metallurgical works situated on the power company's property near the station. These two batteries were normally run separately so that trouble on one should not affect the other. A machine could be shut down only by throwing the two last mentioned batteries together and carrying their combined load on five machines, which could be done at certain times of day. Fig. 8 shows a daily load curve. The three batteries were respectively excited by three of the four turbine-driven exciters running independently of each other.

Among other improvements carried out within the power house during the past year are the following. The brick walls of the new section of the wheelpit have been extended throughout the old section, carrying all leakage from the rock faces through passages behind the brickwork and rendering the whole pit dry and habitable without mackintoshes, which were formerly as essential here as in the Cave of the Winds under the Falls below. With these brick walls the penstocks and shafts may be painted and kept from rusting and consequent depreciation. The complete duplicate oil piping system has been finished for lubricating the thrust (see Fig. 7 and other bearings, and the oil pumping, drying, filtering, and storing system shown in Fig. 9 has been completed. This illustration shows an arch 16 feet wide and 35 feet long, branching from the wheelpit and cut out of the solid rock 130 feet below the floor of the dynamo room. The machine in the foreground is a Worthington duplex pump, the driving cylinders of which are operated by water from the canal above, while the driven cylinders compress air for the pneumatic switch pushers and other compressed air apparatus up above. To the rear may be seen an induction motor which drives a Quimby screw pump for lifting the oil to a reservoir up under the eaves of the power house, from which it circulates by gravity through the bearings and down again to the pit. Another similar pump is provided, coupled to a small turbine. In the background may be seen the oil recuperating system consisting of tanks in which the oil is first boiled and then filtered. The boiling is accomplished by means of electrical heaters, the purpose being to drive off any water that may become mixed with the oil.

The other three arches will be occupied by pumps for the water works system supplying Niagara Falls and two of these pumps are now being installed, one in each of the two arches. The pumps will be driven by 12-foot Pelton water wheels and will each be capable of discharging 6,000,000 gallons in 24 hours against a pressure of 170 pounds.

THE CARBIDE TRANSMISSION.

By far the most interesting of the new developments about the power house is the apparatus installed for delivering 15,000 h.p. to the new works of the Union Carbide Company. Although these works are situated only 11,000 feet from the power plant there are three transformations between the generators and the furnaces, requiring for the amount of power now used, transformers with an aggregate capacity of 50,000 h.p. This is due to the fact that on account of the low cost per kilowatt and high efficiency of the transformers which could be used it proved preferable to step the voltage up at the power house and to change the number of phases from two to three. There was also discovered a peculiar difficulty in transmitting this large amount of power underground at the machine pressure of 2200

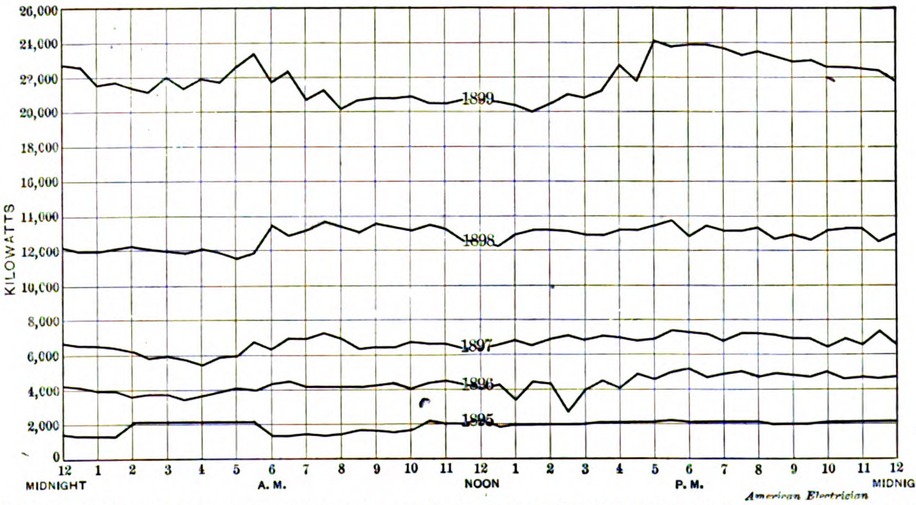


FIG. 8.—A SET OF COMPARATIVE TOTAL LOAD CURVES FOR THE SAME DATE, DEC. 10, OF FIVE SUCCESSIVE YEARS. THEY SHOW THE UNIFORMITY OF THE LOAD THROUGHOUT THE 24 HOURS AS WELL AS THE RAPIDLY INCREASING GROWTH FROM YEAR TO YEAR.

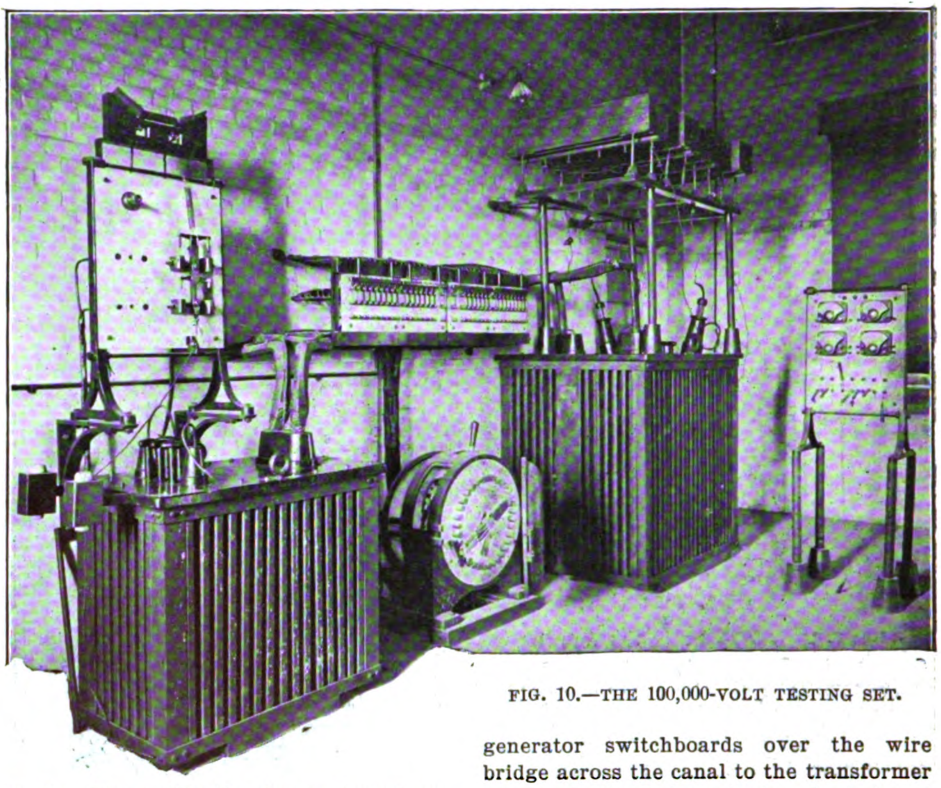


FIG. 10.—THE 100,000-VOLT TESTING SET.

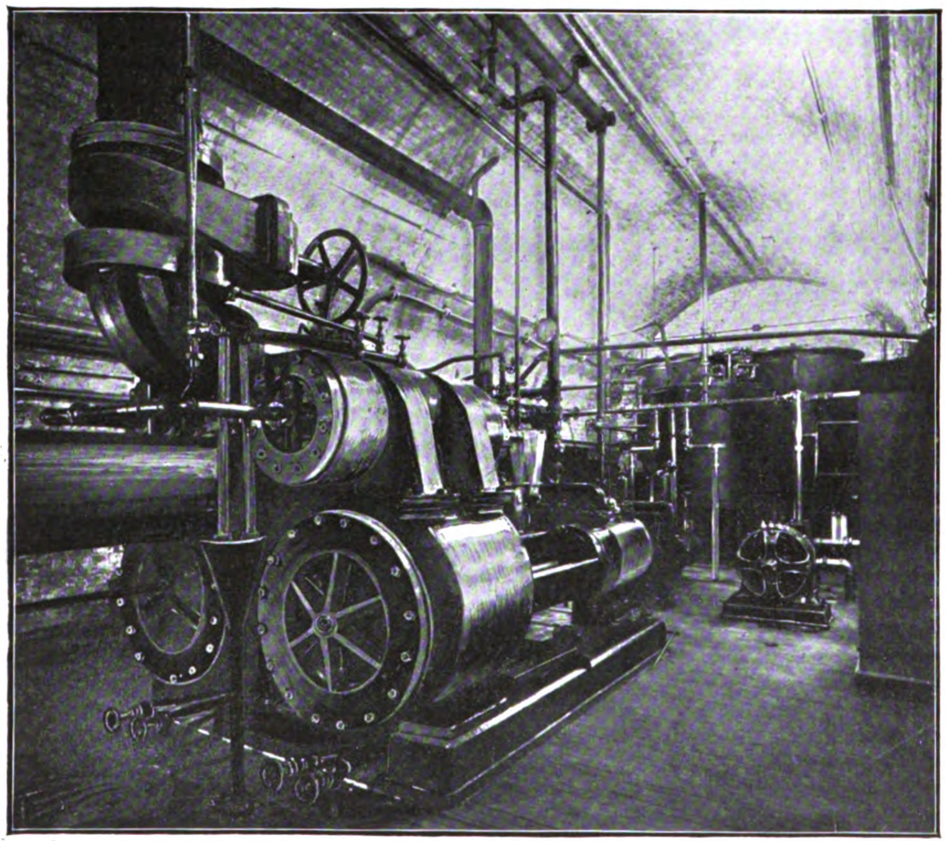
volts, this difficulty being the overheating of the conduit. There is a double step-down transformation at the receiving end.

It has always been considered advisable in connection with this plant to make the rated output of a transforming unit a simple aliquot part of the rated power of one of the generators. A transforming unit in this case consists of two transformers connected on the Scott two-phase three-phase system. Previous to the present year the largest transformers in the world were a battery of 10 transformers rated at 930 kw. or 1250 h.p. each, used to step up the power from this plant for transmission to Buffalo and other distant cities. Of these transformers four, making two two-phase three-phase units, would transform 5000 h.p., the rated output of one generator. The next size larger that could be used conforming with this requirement would be twice as large, each transformer being rated at 1875 kw. or 2500 h.p. This is the size adopted for the carbide transmission.

Fig. 11 shows a view of the step-up transformers in the transformer house of the power plant. Those to either side and in the foreground are the new 2500-h. p. machines, oil insulated and water cooled, built by the Westinghouse Company. In the center background appear the older 1250-h.p. transformers of the forced-draft type made by the General Electric Company and used for the Buffalo line. Fig. 19 shows the six step-down transformers for the carbide transmission in the transformer sub-station near the Carbide Company's works. These, like the step-up transformers, are oil insulated and water cooled, but were built by the General Electric Company.

The diagram shown in Fig. 12 gives the complete through circuits from the generator switchboards in the power plant to the furnaces of the Carbide Company. As may be seen in the top of the diagram there are three feeders leading from the generator switchboards over the wire bridge across the canal to the transformer room. Each of these feeders is designed to carry 5000 h.p. and consists of four single-conductor cables for the four sides of the two-phase system. In the transformer room each feeder ends in a switchboard panel, one of which is illustrated in Fig. 13. This panel contains two circuit breakers, one in one side of each phase, as the diagram shows. The panel also carries throw-over switches, by means of which a spare transformer may be substituted for any one of the other six. For instance, by throwing down the two switches of phase A on any one panel the spare transformer is connected in place of the right-hand transformer connected with that panel, while by throwing down the other two switches the spare one can be made to take the place of the left-hand transformer connected with that panel. The high-tension winding of the spare transformer ends in flexible cables which can be carried down the battery of transformers and connected up temporarily in place of any one of the regular transformers which may fail at any time.

The secondaries of these transformers are connected up as usual for the Scott transformation, one terminal of one secondary, termed the teaser, being connected to the center of the other secondary, termed the main, the three other terminals giving three-phase currents. These three terminals are carried to high-tension panels, where they pass through three ammeters and three switches and thence to the cables leading to the transformer sub-station at the other end of the line. Here the transformers are similarly connected to give two-phase secondary from three-phase primary, the connections at both ends of the line being such that the current goes from teaser to teaser and main to main. The three high-tension circuits from the three pairs of Scott-connected step-up transformers to



IG. 9.—THE AIR AND OIL PUMPING AND OIL RECUPERATING SYSTEM. THIS VIEW SHOWS THE INTERIOR OF AN ARCH QUARRIED INTO THE ROCK 125 FEET BELOW THE LEVEL OF THE GROUND THE PHOTOGRAPH WAS TAKEN ENTIRELY BY THE LIGHT OF INCANDESCENT LAMPS.

the three pairs of Scott-connected step-down transformers are not electrically cross-connected. The step-down transformers, however, are paralleled on their low-tension sides at the bus bars of the 2200-volt switchboard in the step-down sub-station. From these bus bars current is taken to the ten 2000-h. p. transformers of the Union Carbide Company, which reduce it to 110 volts, at which pressure it enters the furnaces.

The circuit breakers in the 2200-volt feeders at the transmitting end are of a new form laid out on what is known as the time-element principle. This principle has been quite generally adopted on Niagara power transmission and has been broadly patented by Mr. L. B. Stillwell, as will be noted by reference to the department devoted to patents on other pages of this issue. The general purpose of the time-element feature is to prevent a short circuit at a point distant from the power house opening any but the nearest circuit breaker to it. For instance, in the diagram of the Carbide transmission it will be seen that the feeders from the 2200-volt bus bars at the receiving sub-station to the 2000-h.p. transformers are protected by circuit breakers. A dead short circuit beyond one of these, however, might trip all of the circuit breakers in the feeders at the transmitting end—if these were made to operate instantly—before the circuit breaker in the one feeder at the receiving end could open and break the arc. For this reason the circuit breakers at the transmitting end are made with a special attachment such that they will only operate if the overload or short circuit holds for a certain length of time, which may be changed by adjusting the apparatus. In case a short circuit occurs beyond a breaker at the receiving end this breaker opens practically instantaneously and cuts off the power before the breakers at the transmitting end get a chance to operate because these latter breakers have the time-element feature. In case a short comes across the lines between the two sets of breakers it of course continues until those at the transmitting end open the circuit.

In construction these time-element circuit breakers (Fig. 13) resemble the ordinary brush-type of circuit breaker built by the Westinghouse Company with arms of sufficient length to break a 2000-volt circuit. The armatures of the tripping magnets of these breakers are connected to levers which extend downwardly toward the rectangular box shown on the face of the board below the two breakers. This box contains a spring-motor mechanism tending to drive a foucault-current disc between the poles of permanent magnets exactly like the retarding mechanism of integrating wattmeters. The motion of this mechanism is restrained by a pawl which is mechanically connected with the tripping mechanism of the breakers. When an overload comes upon either of the breakers its armature moves a slight distance, releasing the spring-motor mechanism, but is restrained from further movement until the spring-motor runs for a certain distance, when the armature of the breaker is left free to move further and operate the trip provided the overload still exists. The time during which the overload must last to operate the breaker is adjusted by moving the magnets on the retarding disc just as the speed of an integrating meter is adjusted. Both breakers, one in each phase, are checked by the same time-element mechanism.

The ammeters on the 11,000-volt side of the step-up transformers are of course not, as indicated in the diagram, connected directly in the circuits. The instruments are supplied through series or current transformers of a new design of the Westinghouse Company, a view of which is shown in Fig. 14. Each of the three 11,000-volt currents passes through a coil contained within two of the long, vertical insulating tubes which are provided to prevent the high pressure from creeping over the surface to the iron core and secondary of the instrument transformer. The flat horizontal iron core is of the figure-eight type surrounding the middle of two of these tubes, and the secondary coil is wound around the central cross-bar of the eight. Below these series transformers there appear in the same illustration the rear connections of the

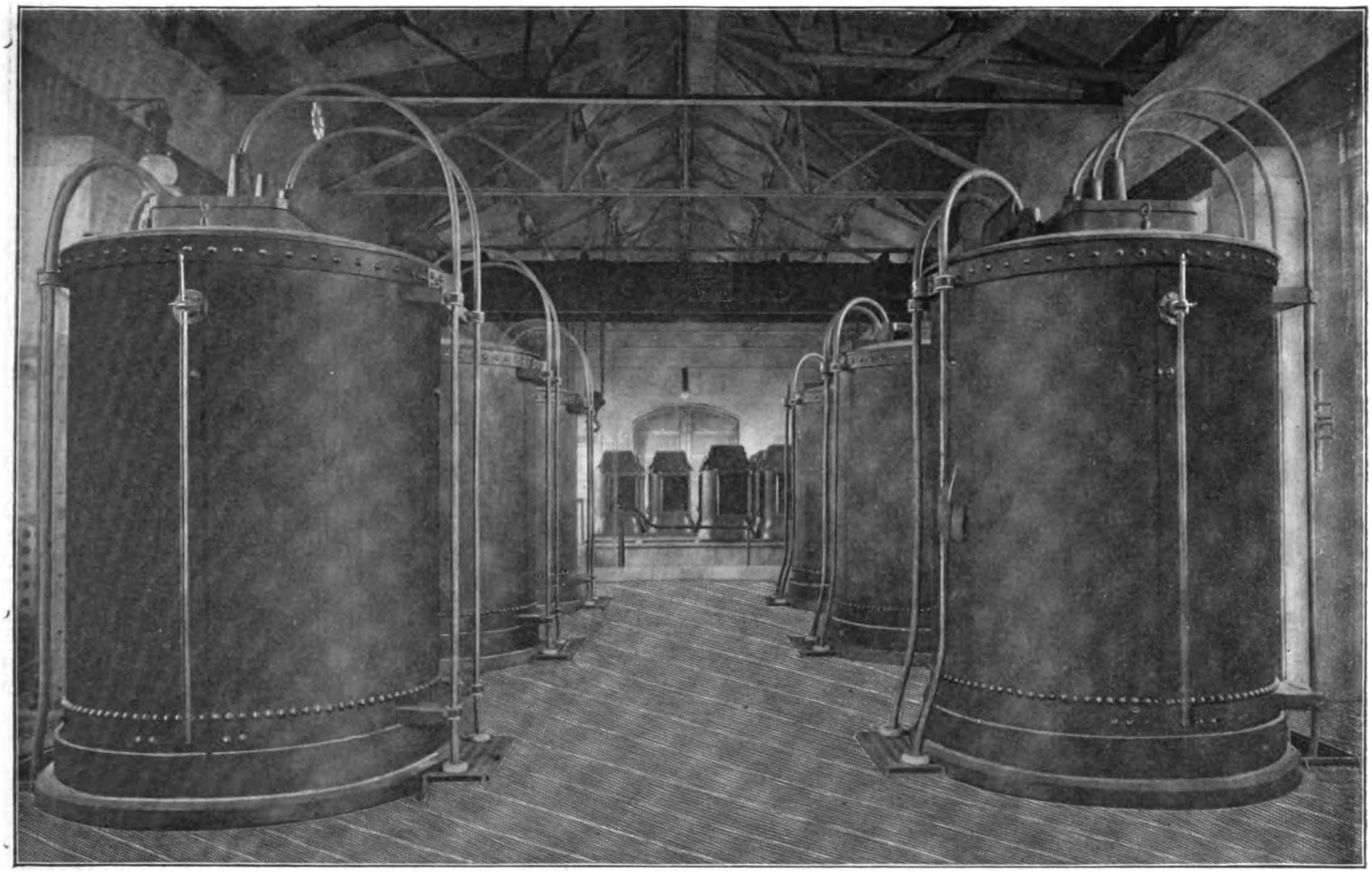
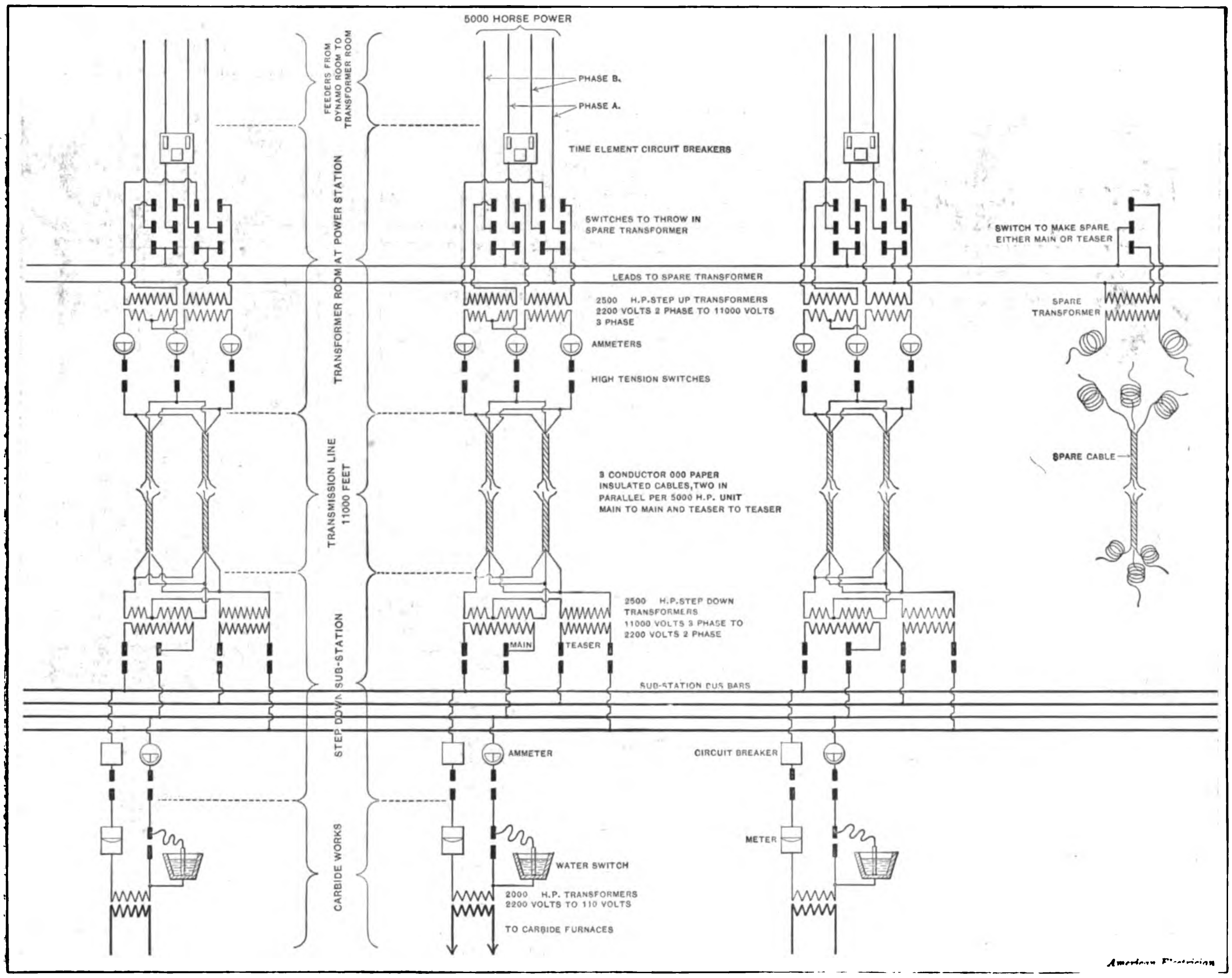


FIG. 11.—THE INTERIOR OF THE TRANSFORMER HOUSE AT THE POWER PLANT SHOWING TRANSFORMERS WITH AN AGGREGATE CAPACITY OF 27,500 HORSE POWER. THE SIX TRANSFORMERS IN TANKS IN THE RIGHT AND LEFT FOREGROUND ARE RATED AT 2500 H. P. EACH THEY ARE USED ON THE CARBIDE TRANSMISSION. IN THE BACKGROUND MAY BE SEEN A FEW OF THE TEN AIR-BLAST TRANSFORMERS RATED AT 1250 H. P. EACH USED FOR THE BUFFALO TRANSMISSION.

high-tension switches. As may be seen, these connections run through long, corrugated hard-rubber tubes to prevent the creeping of the currents. These switches are not intended to be opened under load, but simply to cut off the step-up transformers from the underground cables after the load has been removed by circuit breakers or low-tension switches at some other point.

The cables are at present seven in number, two for each block of 5000 h.p. with one spare. They are triple-conductor 000 and paper insulated, made by the Standard Underground Cable Company. After they were installed the insulation of each conductor was subjected to a test under 20,000 volts pressure applied for half an hour. In this test the other two conductors and the lead were connected together and to the opposite side of the 20,000-volt circuit from that connected to the conductor under test. The whole 87,000 feet of cable stood this test without a breakdown. On account of the capacity of the cable 45 apparent kilowatts were absorbed in each test, that is to say, the capacity current amounted to about 2¼ amperes, which, multiplied by the pressure of 20,000 volts, gives 45 apparent kilowatts, although the real absorption of power was of course much less. The tests for capacity and insulation resistance gave results respectively of .29 of a microfarad per mile and 50 megohms per mile between one conductor as one side of the condenser and the other two and the lead connected together as the other side. The cables were drawn into Camp conduit containing 36 ducts, only seven of which are now used.


5000 HORSE POWER
FEEDERS FROM DYNAMO ROOM TO TRANSFORMER ROOM
PHASE B.
PHASE A.
TIME ELEMENT CIRCUIT BREAKERS
TRANSFORMER ROOM AT POWER STATION
SWITCHES TO THROW IN SPARE TRANSFORMER
SWITCH TO MAKE SPARE EITHER MAIN OR TEASER
LEADS TO SPARE TRANSFORMER
2500 H.P.STEP UP TRANSFORMERS 2200 VOLTS 2 PHASE TO 11000 VOLTS 3 PHASE
SPARE TRANSFORMER
AMMETERS
HIGH TENSION SWITCHES
TRANSMISSION LINE 11000 FEET
SPARE CABLE
3 CONDUCTOR 000 PAPER INSULATED CABLES,TWO IN PARALLEL PER 5000 H.P. UNIT MAIN TO MAIN AND TEASER TO TEASER
2500 H.P.STEP DOWN TRANSFORMERS 11000 VOLTS 3 PHASE TO 2200 VOLTS 2 PHASE
MAIN
TEASER
STEP DOWN SUB-STATION
SUB-STATION BUS BARS
AMMETER
CIRCUIT BREAKER
METER
WATER SWITCH
CARBIDE WORKS
2000 H.P. TRANSFORMERS 2200 VOLTS TO 110 VOLTS
TO CARBIDE FURNACES
American Electrician

IG. 12.—A DIAGRAM OF THE CIRCUITS OF THE CARBIDE TRANSMISSION FROM THE GENERATOR SWITCHBOARD TO THE CARBIDE FURNACES. AS FAR AS THE BUS-BARS OF THE STEP-DOWN SUBSTATION THE POWER IS HANDLED IN 5000-H. P. UNITS BY MEANS OF PAIRS OF 2500 H. P. TRANSFORMERS SCOTT-CONNECTED AND PAIRS OF 000 TRIPLE-CONDUCTOR CABLES.

THE 2500-H.P. STEP-UP TRANSFORMERS.

On account of the size of the transformers used in this installation, which are not only the largest in the world, but twice as large as any previously built, and on account of the interesting nature of their construction they will be described somewhat in detail.

The Westinghouse raising transformers, the interior of one of which is shown in Fig. 16, are of the regulation shell type, with the ends of the coils at the top and bottom of the transformer spread apart to obtain a greater exposure of cooling surface to the oil. The surface of iron exposed to the oil is also increased by spacing strips built in at regular intervals as the iron is assembled. The primary and secondary are interleaved to reduce magnetic leakage and thereby improve regulation, and a great many terminals are brought out from both primary and secondary to make it possible to obtain many different transformation ratios. The transformers are designed to take on their low-tension sides either 2200 or 4400 volts two-phase and deliver on their high-tension sides either 4400, 11,000 or 22,000 volts three-phase. They also have other connections so that any of these voltages on the high-tension side can be raised five per cent—the primary voltage remaining the same—and still other connections so that any transformer can be used as either the main or teaser of a Scott-connected pair. As is well known, the secondary voltage of the teaser of such a pair of transformers should be about 13 per cent less than the secondary voltage of the main. This can be obtained either by winding the secondary with a 13-per cent smaller number of turns and a correspondingly larger cross section, or by simply cutting out and leaving idle 13 per cent of the turns. In the case of these transformers, neither of these two methods is used, but the secondary voltage is reduced by cutting in more turns on the primary or low-tension side of the teaser than are used in the primary side of the main, all high-tension copper being left in in either case. The density is lower in the teaser owing to its greater number of primary turns. Hence its secondary voltage is lower than that of the main. The five per cent increase of secondary voltage for regulation purposes is obtained in a similar way; i. e., by cutting out five per cent of the turns of the primary side and thereby increasing the density and the electro-motive force per turn at the same impressed voltage.

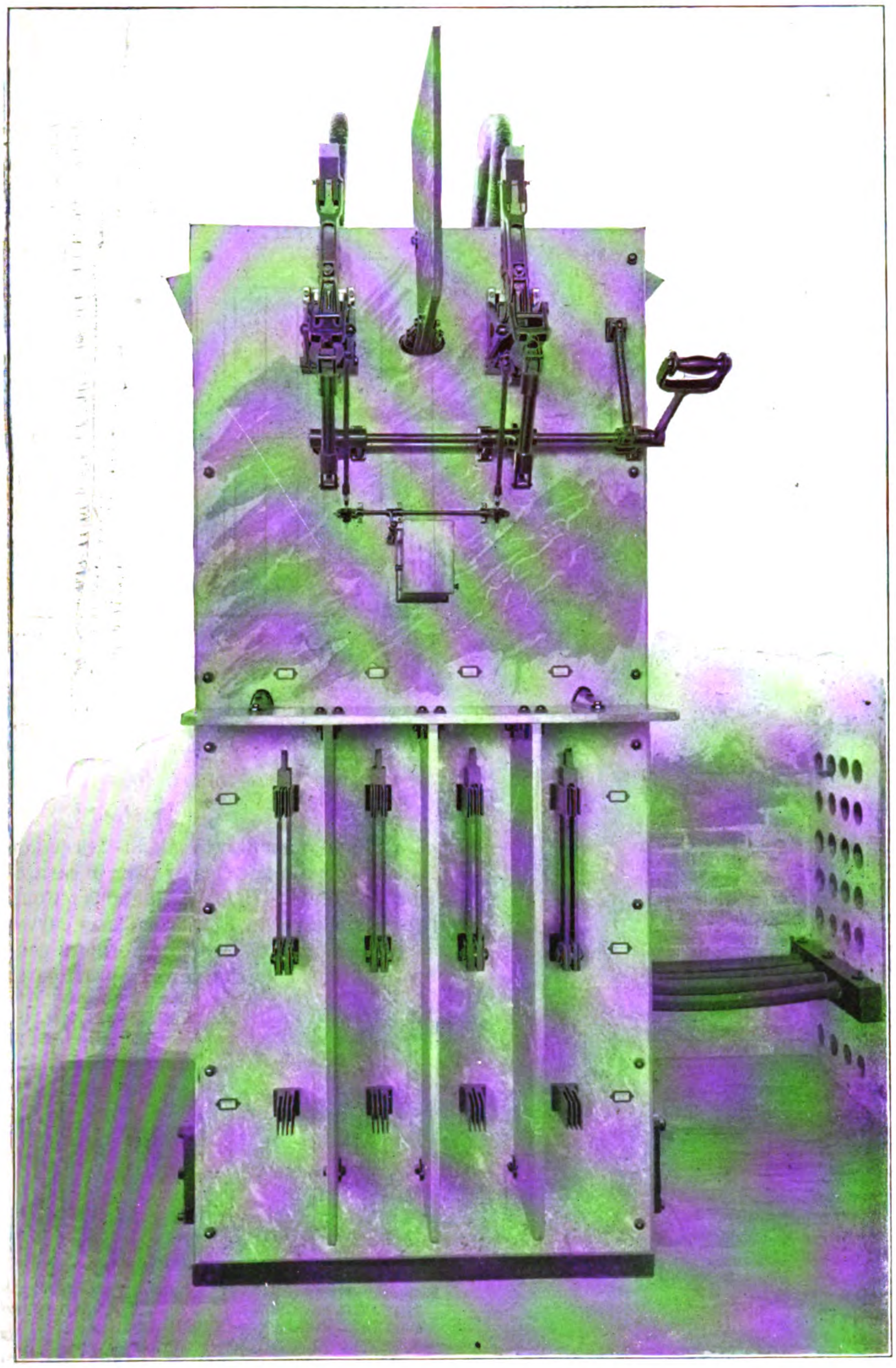


FIG. 13.—ONE OF THE PANELS HANDLING A BLOCK OF 5000 H. P. ON THE LOW-TENSION SIDE OF THE STEP-UP TRANSFORMERS THE CIRCUIT BREAKERS ARE FITTED WITH A TIME-ELEMENT ATTACHMENT. THE SWITCHES ARE FOR THROWING IN A SPARE TRANSFORMER.

There are 600 turns in the high-tension side of each transformer connected in six separate circuits running from the terminal board within the transformer casing, the middle of each circuit being also tapped out to the terminal board (see Fig. 17). Four of these circuits have 120 turns each while two of them have only 60 turns each. These 600 turns are connected all in series for 22,000 volts, two in parallel and 300 in series for 11,000 volts, and five in parallel and 120 in series for 4400 volts. In all cases the middle point of each parallel path through the transformer must be brought out for connection to the teaser when the transformer is used as a main. The connections of the coils for the three different secondary voltages are shown in Fig. 17. It will be noticed that when connected for 22,000 volts, the path from terminal A to terminal B is into the winding at turn 120 and out at turn 1, from which it jumps over to turn 480 and comes out at 300, the rest of the circuit from terminal B to terminal C jumping over in a similar way. This is done to interleave the paths, A B and B C, since when the transformer is used as a main the teaser connection enters at B and the currents in the paths, A B and B C, are out of phase with each other about one-sixth of a period. The leading currents in one side and the lagging in the other must be made to neutralize each other, and this is best accomplished without magnetic leakage by interleaving the windings. A similar arrangement can be traced in the 11,000-volt connection while in the 4400-volt connection the splitting up of the 60 turn coils each side of the terminal, B, accomplishes even more perfectly the same result.

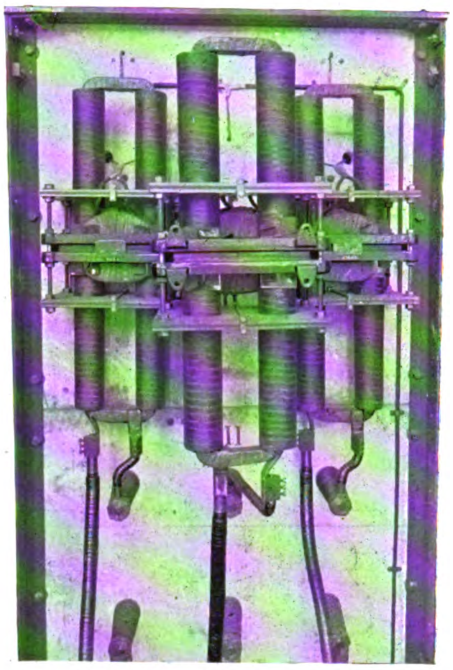


FIG. 14.—HIGH-TENSION CURRENT TRANSFORMERS FOR AMMETERS. THE LONG TUBES CONTAIN THE HIGH-PRESSURE CONDUCTORS AND ARE DESIGNED TO PREVENT SURFACE LEAKAGE OR CREEPING.

The low-tension side of each transformer contains altogether 272 turns connected throughout in two parallel paths, as indicated in Fig. 18. For 4400-volt supply, these two double paths are connected in series, but for 2200-volt supply they are connected in parallel. For normal ratios of transformation all the secondary turns are used, while to obtain the five per cent. increase the three-turn sections are cut out. When the transformer is used as a main the eight-turn sections are cut out, while for use as a teaser these eight-turn sections are cut in, thereby reducing the e. m. f. per turn, and in consequence the secondary pressure to the proper value for the teaser side of the Scott connection. One incoming lead to the spare transformer (see Fig. 12) is connected through a throw-over switch, mounted on the transformer case, so connected that when the switch is closed in one position the whole number of pri-

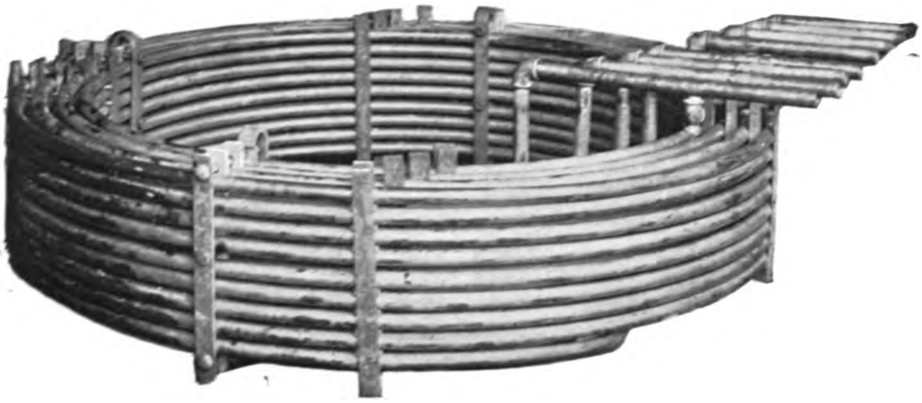


FIG. 15.—THE COOLING COILS OF THE TRANSFORMER SHOWN BELOW.

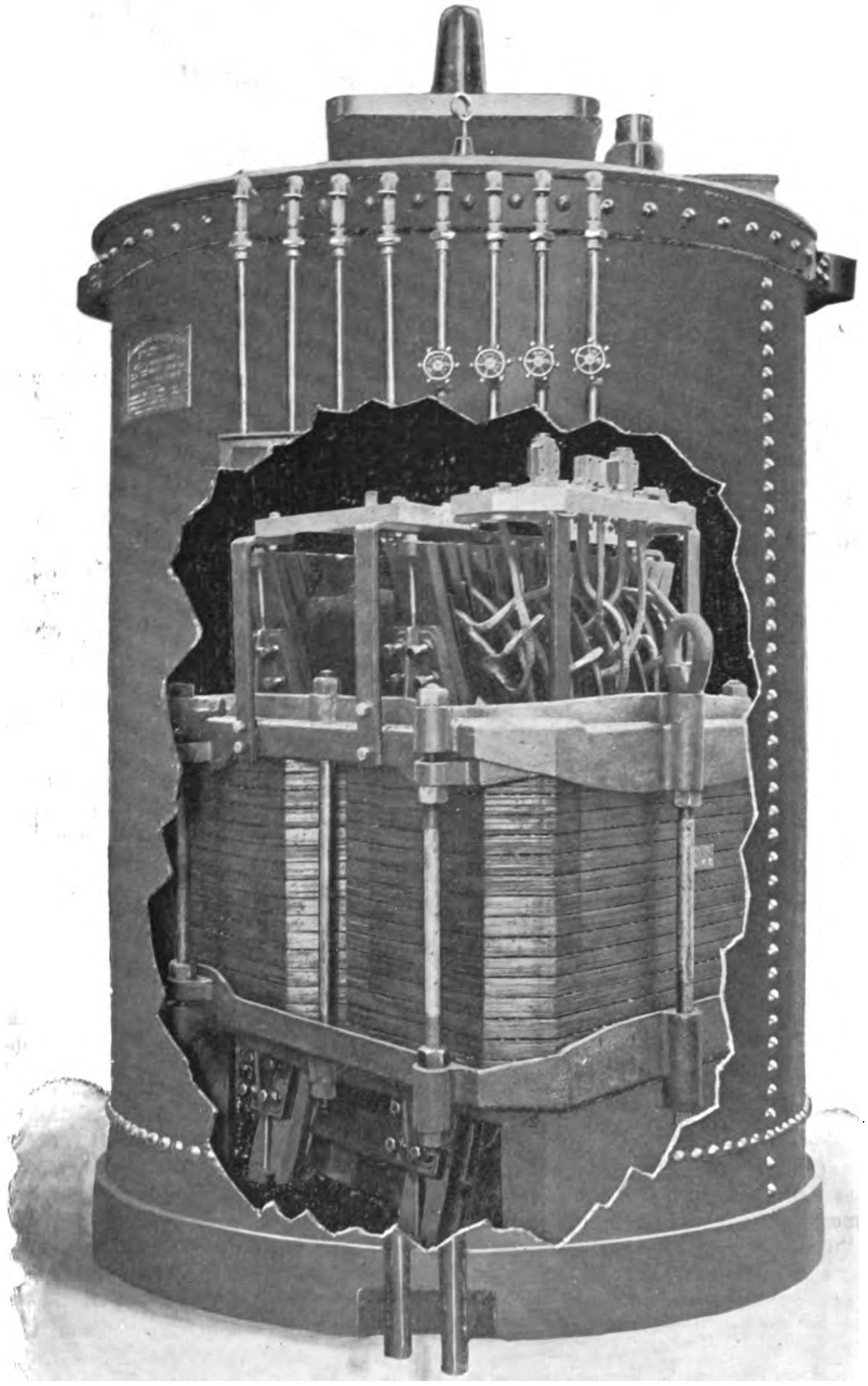


FIG 16.—ONE OF THE 2500-H. P. STEP-UP TRANSFORMERS WITH THE CASE INDICATED AS BROKEN AWAY TO SHOW THE INTERIOR.

mary turns are cut in, while closed in the other position the proper number are cut out to change the transformer to a main.

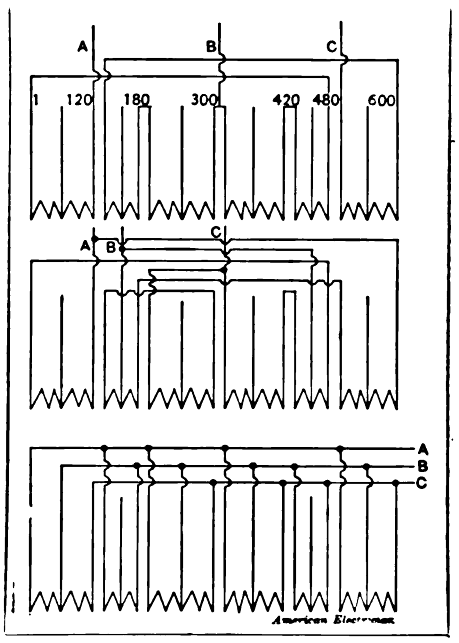


FIG. 17.—THE CONNECTIONS OF THE HIGH-TENSION COILS OF THE STEP-UP TRANSFORMERS, SHOWING HOW THE CENTRAL TAP OF THE MAIN FOR THE CONNECTION OF THE TEASER IS BROUGHT OUT IN ALL CASES, AND HOW THE TWO SIDES OF THE MAIN ARE INTERLEAVED. THE UPPER DIAGRAM SHOWS THE CONNECTIONS FOR 22,000 VOLTS; THE MIDDLE ONE THOSE FOR 11,000 VOLTS AND THE LOWER THOSE FOR 4400 VOLTS.

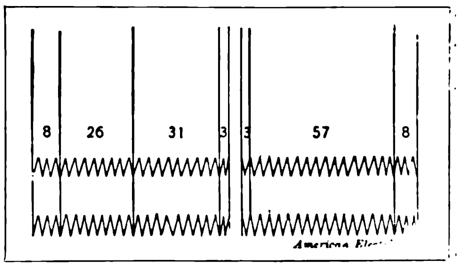


FIG. 18.—THE CONNECTIONS OF THE LOW-TENSION COILS SHOWING HOW ANY TRANSFORMER CAN BE USED AS A MAIN OR TEASER AND HOW A FIVE PER CENT RISE OF VOLTAGE CAN BE OBTAINED IN EITHER CASE.

The regulation of these transformers is one per cent., i. e., the secondary pressure only falls off one per cent. on the application of full non-inductive load from the pressure at no load, the voltage applied remaining the same. When working at 11,000 volts secondary, this drop of voltage amounts to about 110 volts. Efficiency and loss curves from measurements made by the Westinghouse Company are shown in Fig. 20. These curves are the average of two transformers connected up just as they are in practice to change from two phases to three phases. They include, therefore, the increased copper loss in the secondary of the main and the diminished iron and increased primary copper losses of the teaser. The efficiency, therefore, is not quite as high as it would be were the transformers used with the same number of phases on the primaries as upon the secondaries. The weight of a complete transformer without oil is approximately 24,000 pounds, the oil adding about 5000 pounds to the weight of each transformer.

THE STEP-DOWN TRANSFORMER SUB-STATION.

Near the new works of the Union Carbide Company the Niagara Power Company has built a small brick structure about 130 by 30 ft. in size, for housing its 11,000-volt to 2200-volt transformers and 2200-volt receiving and distributing switchboard. The building is served by a hand crane and a spur from the railroad track enters one end so that transformers can be lifted from railroad cars direct by the crane. The building now contains 7 General Electric transformers, one more than is shown in Fig. 19, and has foundations for 4 more, with a temporary wall at one end so that it can be extended.

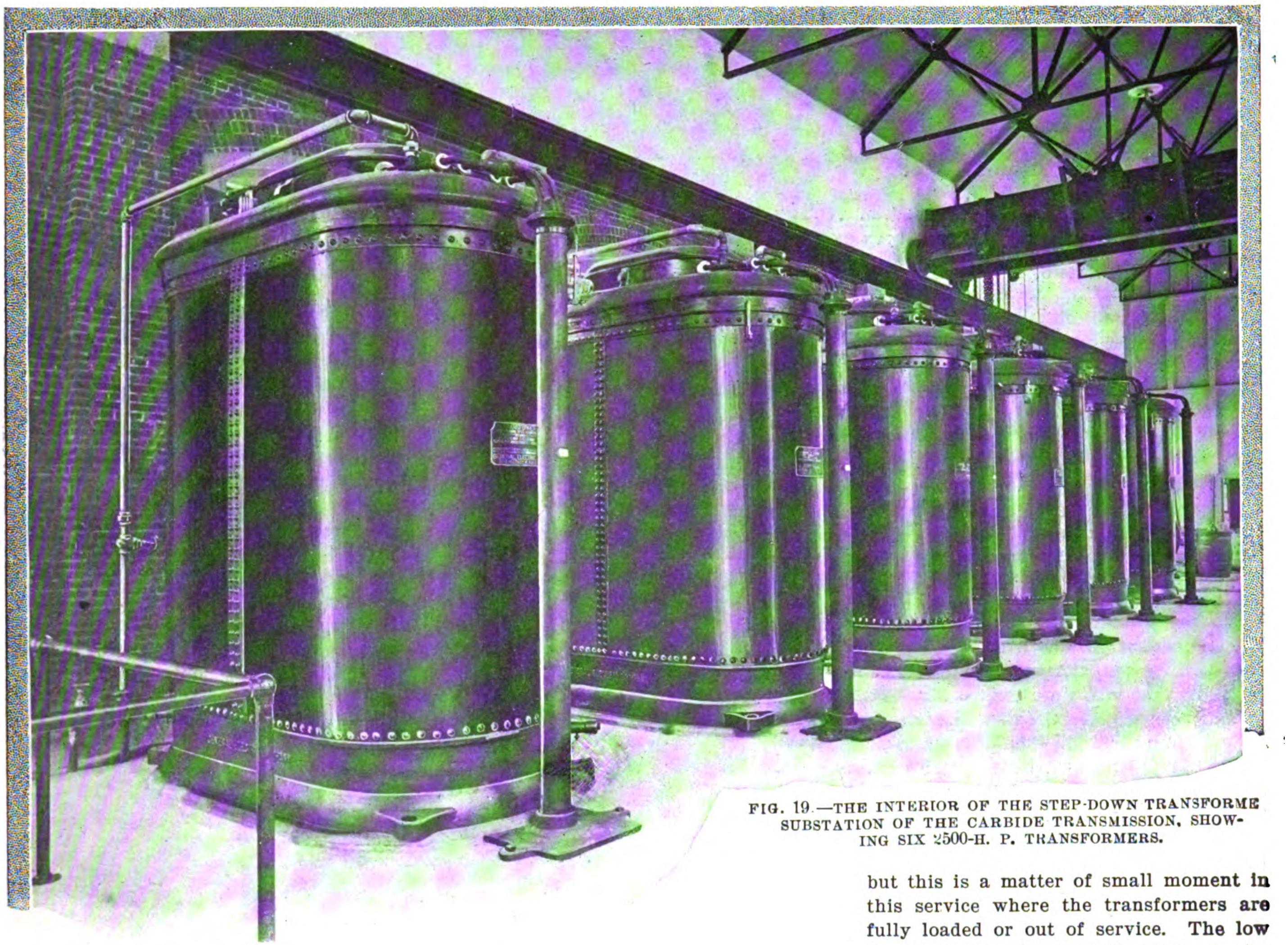


FIG. 19.—THE INTERIOR OF THE STEP-DOWN TRANSFORME SUBSTATION OF THE CARBIDE TRANSMISSION, SHOWING SIX 2500-H. P. TRANSFORMERS.

The high-tension leads enter from the conduit through a pit or subway running down one side of the room behind the transformers, and are carried up over and to the transformers in substantial standpipes. All connections of both high and low-tension wiring, as well as of the piping around the transformers, are made with unions, so that a transformer can be readily removed or replaced and the spare transformer or the spare cable can be readily put in service in place of any of the regular apparatus. As the diagram of connections, Fig. 12, shows, the incoming cables run direct to the high-tension sides of the transformers, with no intermediate switches, circuit breakers or other devices. A Quimby screw pump is direct coupled to a small induction motor for use in filling or emptying any one of the transformer cases from a 23-barrel tank of oil.

These transformers differ considerably from those of the same power built by the Westinghouse Company for stepping up the voltage at the other end of the line. The coils in these step-down transformers lie in horizontal planes, making the plan of the transformer elliptical, the boiler-iron base being 11 feet high, 8 feet long and 4 feet wide. The total weight of each transformer, with case, is about 50,000 pounds, about double that of the step-up transformers. The step-down transformers are not wound for 22,000 volts on their high-tension sides, but only for 11,000. The low tension may be either 2200 or 4400. Each can be used as either a main or a teaser.

The cooling of the coils in the transformers is accomplished in an entirely novel way. The coils are of the flat edgewise type, the primaries alternating with the secondaries and with one laid on top of another. Directly between these edgewise layers are inserted flat brass pipes through which the cooling water is circulated. Other coils of pipe are used as usual to cool the oil, which, in turn, cools the core. The iron loss of each of these is given by the General Electric Company as 22,600 watts, the copper loss 8700 watts, the regulation 0.5 per cent, and the rise of temperature, after eight hours' run at full load 45° C. The efficiency curve as given by the company is shown in Fig. 21.

Comparing these curves with those of the step-up transformers, Fig. 20, it will be seen that, although the total losses at full load are about the same, the iron losses of one are over twice those of the other, while the copper losses are correspondingly less. Heavy iron losses cause, of course, low efficiencies at low loads, but this is a matter of small moment in this service where the transformers are fully loaded or out of service. The low copper loss and extremely close regulation of the G. E. transformers indicate that there is a small amount of copper in them, but their great weight shows that any saving in cost of copper is balanced by cost of iron.

The secondary circuits of these transformers lead to two similar switchboards, one of which is illustrated in Fig. 23. As may be seen, this switchboard contains an odd assemblage of General Electric, Wagner and Westinghouse apparatus. The central panel contains the incoming switches from four of the transformers just described. Flanking it on either side are distribution panels leading to the 2000-h. p. transformers scattered about the carbide works for lowering the pressure to 110 volts. Each panel is fitted with a voltmeter and ammeter, two switches and a Westinghouse brush-type circuit breaker.

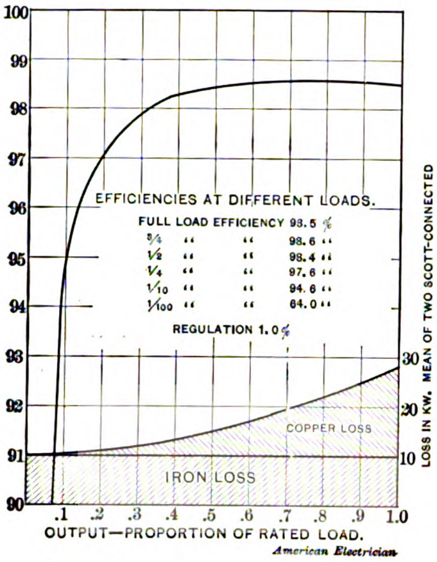


FIG. 20.—WESTINGHOUSE.

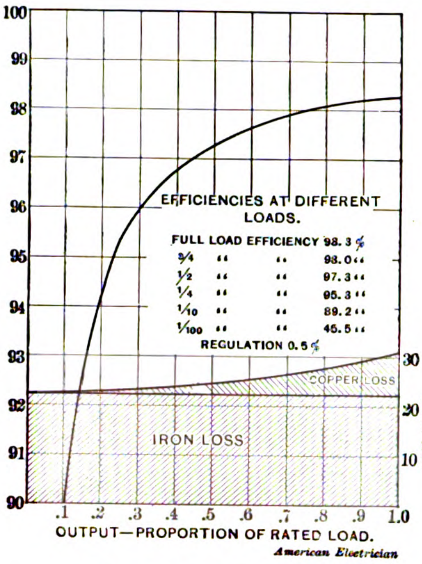


FIG. 21.—GENERAL ELECTRIC.

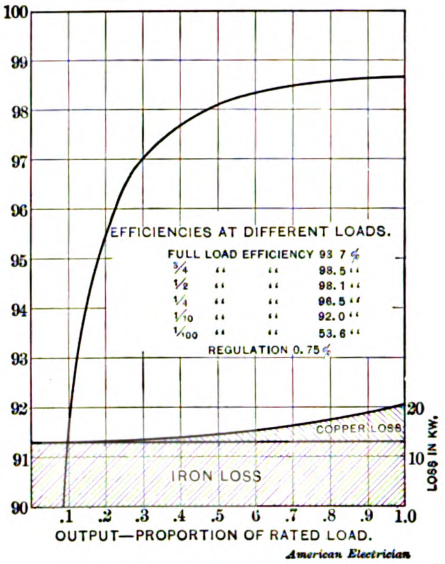


FIG. 22.—WAGNER.

EFFICIENCY AND LOSS CURVES OF THE THREE MAKES OF TRANSFORMERS USED ON THE CARBIDE TRANSMISSION. THE CURVES OF THE WESTINGHOUSE TRANSFORMERS ARE THE MEAN OF TWO CONNECTED FOR TWO-PHASE THREE-PHASE WORK AND INCLUDE THE SLIGHTLY REDUCED IRON LOSSES OF THE TEASER AND THE INCREASED COPPER LOSSES OF BOTH MAIN AND TEASER. IN COMPARING THE LOSSES OF FIG. 22 WITH THE OTHERS, THE FACT SHOULD BE REMEMBERED THAT THE WAGNER TRANSFORMERS ARE ONLY RATED AT FOUR-FIFTHS OF THE RATED CAPACITIES OF THE OTHER MAKES.

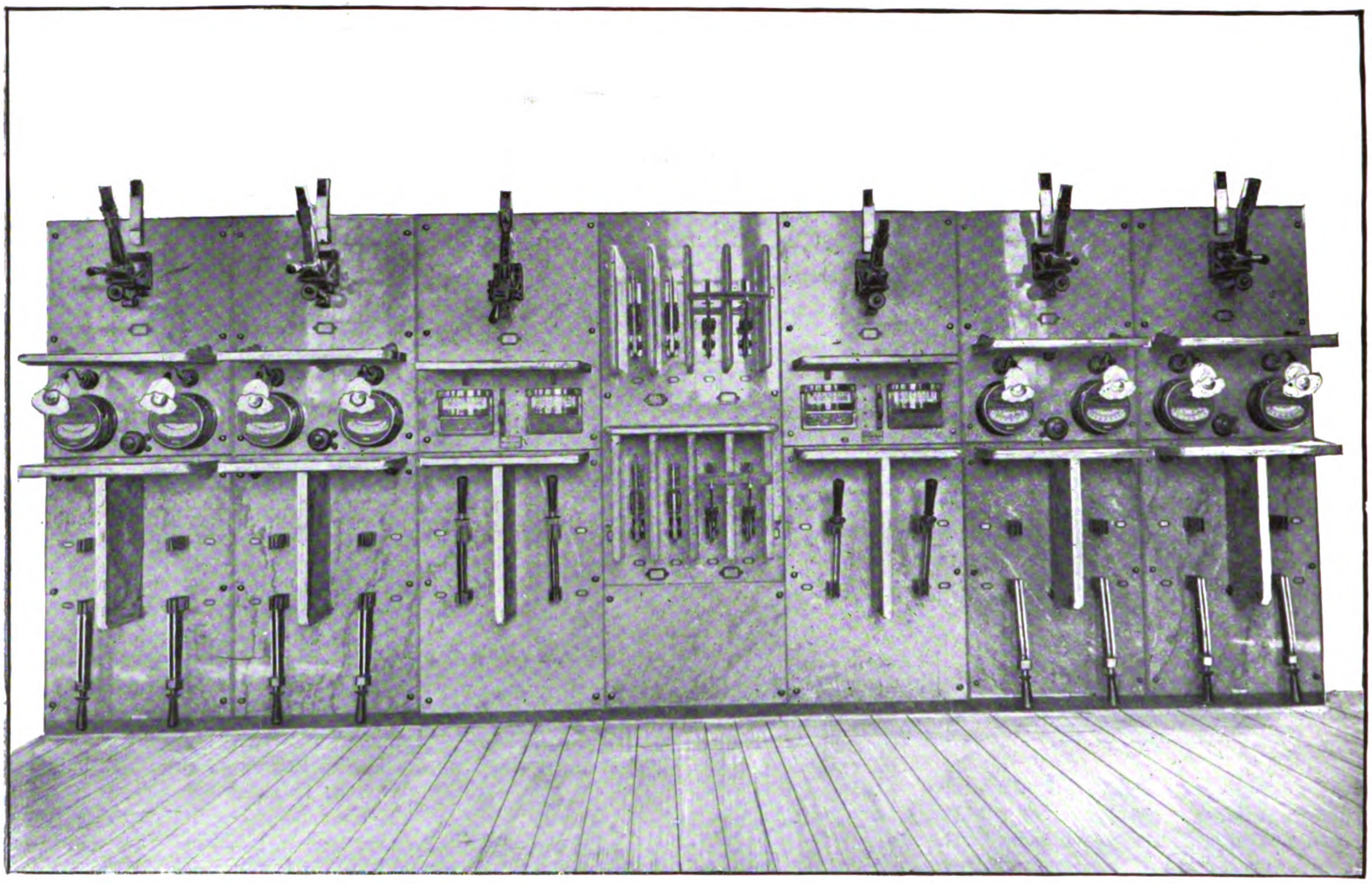


FIG 23.—ONE OF THE TWO 2200-VOLT SWITCHBOARDS OF THE CARBIDE SUBSTATION. THIS BOARD RECEIVES IN THE MIDDLE PANEL THE OUTPUT OF FOUR OF THE 2500-H.P. STEP-DOWN TRANSFORMERS SHOWN ON THE LAST PAGE, AND DISTRIBUTES THIS OUTPUT THROUGH THE OTHER PANELS TO THE 2000-H.P. TRANSFORMERS SHOWN ON THE NEXT PAGE.

THE 2000-H.P. 2200-VOLT TO 110-VOLT TRANSFORMERS.

The transformers which still further lower the pressure to that required by the carbide furnaces are somewhat smaller than the step-up and step-down transformers mentioned above, being rated at 1500 kw. or 2000 h.p. each, while the transformers already described are rated at 1875 kw. or 2500 h.p. each. The 2000-h.p. transformers were built by the Wagner Electric & Manufacturing Company. Like the others described above, they are oil-insulated and water-cooled and are guaranteed to operate continuously at three-quarters load without the use of the water coils, dissipating all the losses by the cooling of the boiler iron case with a rise of temperature not to exceed 40° C. They are guaranteed to run under full load with a water flow of three gallons per minute with the same rise of temperature above atmosphere.

These transformers are scattered, in order to bring them near the furnaces, which is necessary on account of the low secondary voltage, each being located in a small transformer house built in the form of a lean-to beside the main structure of the carbide works. The transformer houses are designed to give liberal air circulation for cooling purposes. The covers of the transformers themselves, on account of the dusty location, are made absolutely dust-proof in all joints.

A view of one of these transformers with the exterior indicated as broken away to show the coils and core is given in Fig. 24. The coils lie in vertical planes and the laminations of the core in horizontal planes, the arrangement of the spacing blocks and the plates and clamping bolts being clear from the illustration. The 110-volt secondary comes out of the top of the transformer in a large number of heavy copper straps to which interleaved leads are bolted for carrying the current to the furnaces. The copper bars forming the leads are interleaved (i. e., those of one polarity are interspersed between those of the other polarity) in order to reduce the self-induction and particularly the skin effect which would be very serious were this amount of current (between 13,000 and 14,000 amperes) carried with all the conductors of one polarity in one group and all the conductors of the other polarity in another group.

The transformers are wound for a voltage ratio of 4400 or 2200 volts to 220 or 110 volts. In actual practice the windings are connected for a ratio of 2200 to 110. The parts are guaranteed to withstand an insulation test of 10,000 volts alternating between high-tension coils and iron and 5000 volts between the core and the containing case. Tests under these pressures were made on each of the transformers after it had been operating continuously for 24 consecutive hours, the duration of the tests being 30 minutes on each transformer. Each transformer is further built to withstand an overload of 50 per cent without deleterious effects of any sort for a period of five minutes. All transformers were subjected to a 30-day duty test prior to their acceptance by the Carbide Company and complete electrical tests were made at the carbide plant. The loss and efficiency results obtained from these tests are plotted in Fig. 22, the curves and figures given being the mean results of seven transformers calculated from an iron loss obtained in the usual way and copper loss obtained by wattmeter measurements.

An interesting point in connection with the tests made at the Wagner factory in St. Louis and the tests at Niagara Falls is the fact that the former showed an iron loss about 1½ kw. less than the latter. This is due to the use of a smooth-body generator in the former test, which generates a sinusoidal e.m.f. wave giving a lower iron loss than the flat-topped wave of the Niagara generators.

A few of the details of construction of these transformers are of interest. A requirement of the water-cooling coils is that they should be absolutely free of any risk of leakage since the leakage of water into the oil of the transformer would of course cause a break down of the insulation. The water-cooling coils of these transformers are of seamless copper tubing, sufficient to withstand a pressure of 325 pounds, but subjected by the Wagner Company to a test pressure of 625 pounds before shipment to the carbide plant. These cooling coils are made with welded joints inside the transformer case, and as the pressure is only a trifle above atmosphere they can be depended upon to be absolutely free from leaks. Each transformer is equipped with an oil gage for indicating the level of the oil and each oil gage has enclosed within it a thermometer which indicates the temperature of the oil at the upper surface of the oil body.

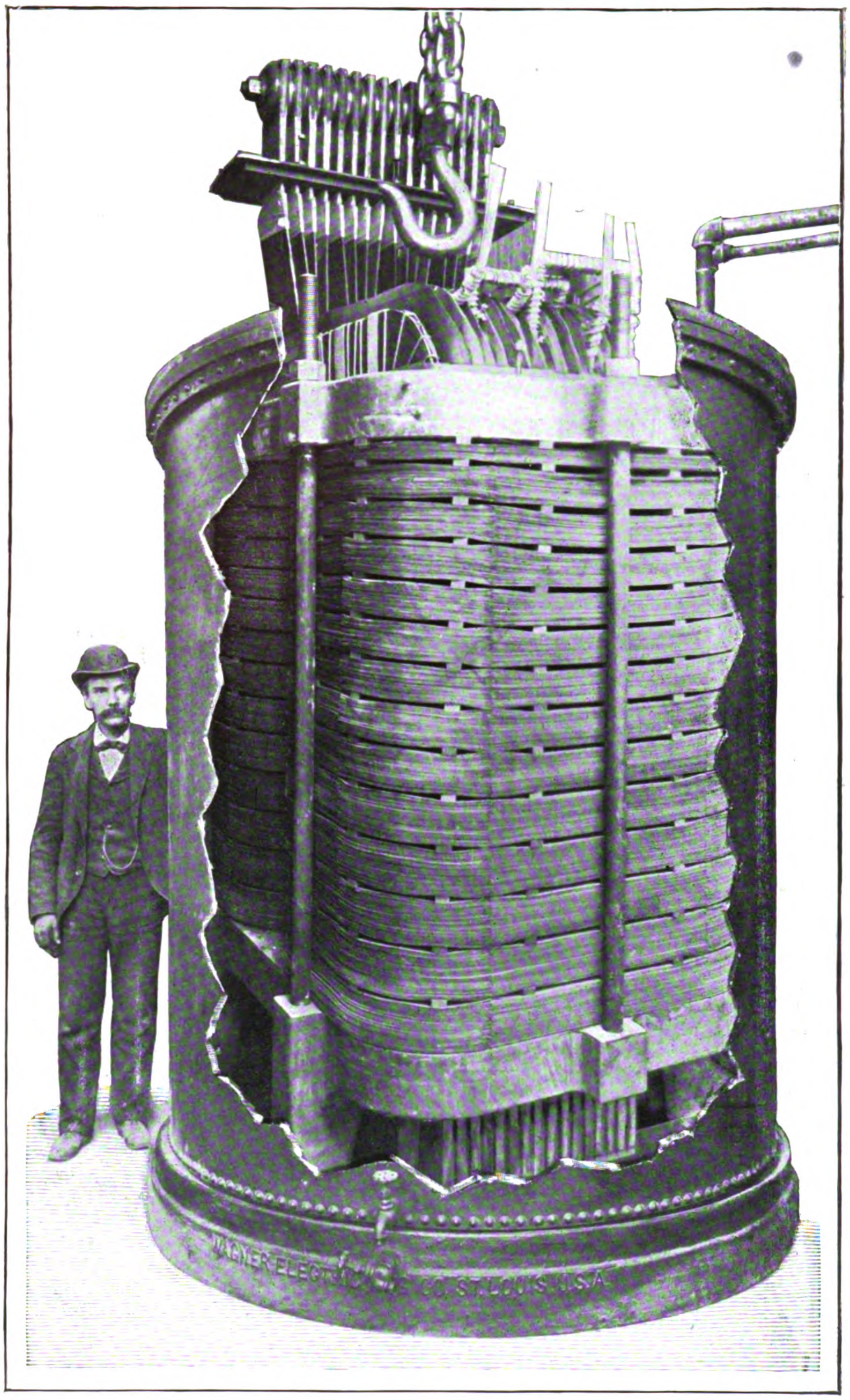


FIG. 24.—ONE OF THE 2000-H.P. 2200-VOLT TO 110-VOLT WAGNER TRANSFORMERS SHOWING THE INTERNAL PARTS WITH THE EXCEPTION OF THE COOLING COILS.

The 110-volt secondary comes out in a large number of heavy copper straps to which interleaved leads can be bolted for carrying the current to the furnaces. The power is metered at the primary terminals of these final transformers by ordinary integrating meters mounted in the transformer rooms. The primary circuits in the same location also contain water switches for cutting off the power in case of emergency. A water switch consists of a metal pail or tank filled with water, and a cast-iron rod which can be lowered into it. This arrangement is shunted by an ordinary knife switch to obtain good contact. The arrangement is shown in the diagram of connections. In operation the knife switch is first opened, throwing the current through the rod and water. The rod is then raised, throwing the water into the path of the current and finally drawing an arc between the surface of the water and the lower end of the rod. If the water is of sufficiently high resistance, the power is cut off gradually as the rod is raised, so that there is but little arc when the circuit is finally broken. This arrangement is a highly effective one, as the arc finds little to feed upon with water as one electrode, and is not injurious to either terminal.

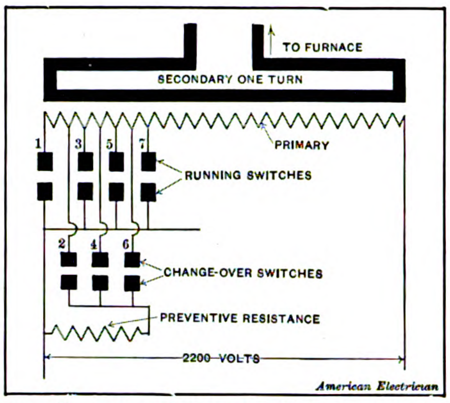


FIG. 26.—THE SCHEME OF THE SWITCHING ARRANGEMENT FOR VARYING THE RATIO OF TRANSFORMATION OF THE 37,500-AMPERE TRANSFORMER.

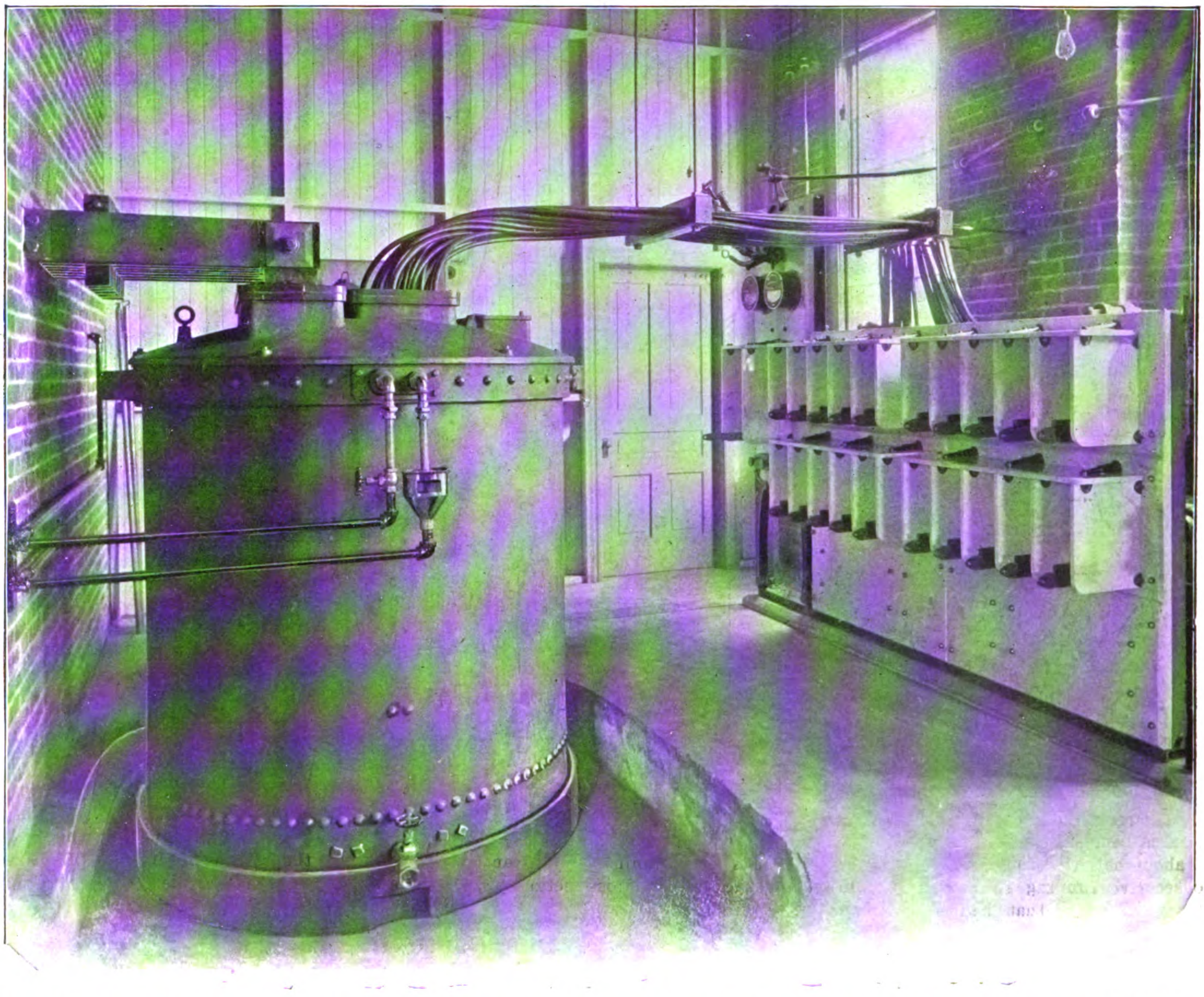


FIG. 25.—THE 37,500-AMPERE TRANSFORMER AT THE NEW WORKS OF THE ACHESON GRAPHITE COMPANY AND ITS VOLTAGE REGULATING SWITCHBOARD.

A 37,500-AMPERE TRANSFORMER.

As has been previously noted in these columns, Mr. E. G. Acheson, the discoverer and founder of the electrical process for making carborundum, has been at work developing an electrical process for making graphite from amorphous carbon, or coke. A small plant containing one furnace has been built on the property of the Niagara Power Company, adjoining the carborundum works, an interesting feature of this plant being the transformer which lowers the voltage to that required by the furnace. Owing to the low resistance of both the raw material and the finished product, this pressure is very low, varying from 12 to 30 volts. On this account the transformer, which is rated at 450 kw., bears the distinction of delivering the largest quantity of electrical current of any single machine the world over. The transformer is designed to deliver its full rated power of 450 kw. at either 30 volts, 12 volts, or any one of a number of intermediate steps, the rated secondary current therefore being inversely proportional to the secondary pressure. At 12 volts the current required to deliver 450 kw. amounts to 37,500 amperes.

The transformer and its accompanying switchboard are shown in the illustration reproduced on this page. The transformer itself is of the usual oil insulated and water-cooled type, cased in a boiler-iron tank about 64 inches in diameter and six feet high. Its secondary circuit naturally consists of a single turn of very massive copper bars, and these run out through the top of the transformer to the heavy leads shown in the illustration, which run through the wall to the furnace on the other side. These leads consist of 16 copper bars, eight for each pole, the bars of the two polarities being interlaced to reduce the inductive effect; each bar is 6 inches by ⅞ inch in cross section. By means of the interlacing the power factor, as measured on the primary, has been brought up to about 85 per cent., which is quite an achievement considering the fact that the circuit carrying this enormous current at a very low voltage must embrace a considerable area for inductive action at the furnace itself, no matter how carefully the leads thereto may be interlaced.

Another interesting feature of this plant is the means of varying the secondary pressure from 30 to 12 volts, or vice versa. Naturally, the secondary circuit itself is not subject to any manipulation in the way of changes of connections, and all alterations must be carried on in the primary, or 2200-volt side. The voltage of the secondary is varied by changing the number of primary turns in circuit across the 2200-volt line, this variation changing the electromotive force per turn within the transformer by changing the density of the alternating magnetic field set up in the iron. This change of density naturally changes proportionally the voltage set up in the one secondary turn. Without any interruption of the circuit the variation of the number of primary turns is made by means of switches and a very simple arrangement of preventive resistances, which was made available by reason of the fact that the load is constant.

The arrangement of the switches is indicated partially in Fig. 26. The total number of steps from maximum to minimum turns in the primary is 20, 11 of these being running steps on which the transformer may be worked for any length of time, and the other nine merely intermediate change-over steps connected through resistances which are not supposed to carry the load permanently. If any one of the running switches, 1, 3, 5, etc., is closed, the incoming line to the left is connected directly into the transformer winding at a point dependent upon the switch closed. Between the points at which these switches are tapped into the winding there are other taps running to change-over switches, 2, 4, 6, etc., which are connected with the incoming line only through a resistance. This resistance is sufficient with the normal primary current, about 240 amperes, which remains constant, to cause a drop equal to about half the drop between any two consecutive running switches. For instance, supposing that the transformer is running with switch No. 1 closed, thus delivering the lowest voltage to the secondary, the first change to raise the voltage would be the closing of switch No. 2. This would connect the preventive resistance in parallel with the few turns of the primary between switches 1 and 2. Switch 1 would then be opened and the whole primary current of about 240 amperes would flow through the resistance and in through switch 2, causing a slight increase of the secondary voltage due to the reduced number of primary turns, and in spite of the resistance in the primary. Switch No. 3 would then be closed, throwing the resistance in parallel with the section of the primary between switches 2 and 3. Switch No. 2 would then be opened, leaving the circuit closed to the running point, 3. A similar sequence of events would be followed in changing over to other running switches, intermediate switches connected with the resistance being used in every case, so that there would be at no instant an interruption of the circuit or a short circuiting of any part of the transformer winding.

The switches are of a quick-break type, designed to handle the large primary current. They appear projecting from cells on the front of the switchboard shown in the photographic illustration. They are not fitted with handles, but simply have holes in which a hook on the end of a wooden pole may be inserted. The resistances used are of an iron-clad type similar to street railway diverters. The whole installation was made by the Westinghouse Electric & Manufacturing Company.

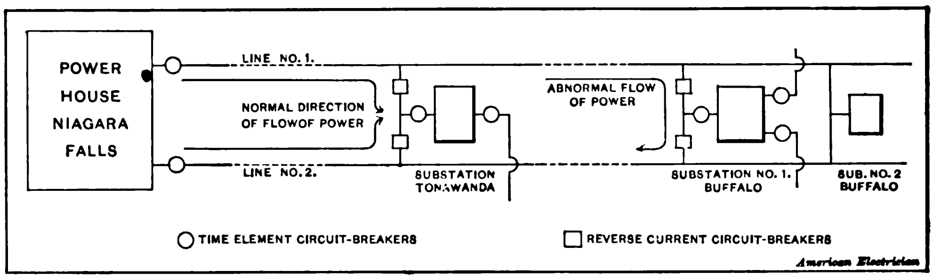


FIG. 27.—A DIAGRAM ILLUSTRATING THE LOCATION IN THE LINES AND THE PURPOSE OF THE TIME ELEMENT AND REVERSE CURRENT CIRCUIT BREAKERS.

The transformer works at approximately constant loss and constant efficiency over its considerable range of voltage. This is due to the fact that as the number of turns is reduced the copper loss in both the primary and secondary is reduced, but the iron loss is increased, and vice versa, thus giving no considerable variation of the total loss. Since the total power continues constant, the efficiency remains nearly the same throughout the range of work of the transformer.

THE NIAGARA-BUFFALO TRANSMISSION LINE AND ITS PROTECTIVE ARRANGEMENTS.

Some interesting detail changes have recently been made in the overhead transmission line from Niagara Falls to Tonawanda and Buffalo. As readers of the electrical papers may remember, this line consists of six uninsulated stranded cables, each with a cross-section of 350,000 c. m., the three cables of one three-phase circuit being on one side of the poles, while those of the other circuit are on the other side of the poles. Originally these six cables were supported on one six-pin cross arm, with a distance from pin to pin of only 18 inches between centers. On account of the mischievous interference of the ubiquitous small boy this arrangement has been changed; the center wire of each three-phase line has been dropped to a lower cross arm, giving a triangular arrangement of the three wires of each circuit. With the old arrangement, boys, and perhaps other mischief makers, improved the opportunity to throw pieces of wire, barrel hoops, or other metal objects over the line, starting violent 11,000-volt arcs, which often held between the wires 18 inches apart and were blown by the wind along the pole line, to the delight of those who started the arc but to the distress of both the generating and receiving stations. With the new arrangement the minimum distance between the wires is 36 inches, across which an 11,000-volt arc would probably not hold, and across which it is more difficult to lodge a short piece of wire. The lines are spiralled in the same places that they were formerly.

Another detail change on the line is the removal of the guard wires, which were intended to serve as lightning arresters. These have been taken down, as the trouble they caused through falling over the line wires proved greater than any probable benefits. There are no line arresters on the circuit, i. e., lightning arresters are only in use at the transmitting end, at the Tonawanda sub-station (which taps the line), and at the Buffalo terminal house, where the line goes underground.

The line is still worked at a pressure of 11,000 volts, the contemplated change to 22,000 volts not having been made as yet. At present, owing to the lack of sufficient generating equipment to meet all demands for power, the Buffalo end of the system is limited to about 10,000 h. p., which can be carried over the present line without excessive drop. When more power is available, and is utilized in Buffalo, more copper or a higher voltage will be necessary. Present plans contemplate installing, during the coming summer, another independent pole line between Niagara Falls and Tonawanda to reinforce the present line up to that point, the load on that part of the line being heavier than on the rest of the line into Buffalo owing to the fact that the Tonawanda station absorbs no small amount and the Lockport line is tapped off at Tonawanda. A new and separate line of poles will be run to avoid an interruption of the supply through the fall of a pole on either line. The new line will be erected on the other side of the 30-foot right of way, one side of which is now occupied by the present pole line.

To further provide for the expected increase of loads in Buffalo it is proposed to raise the line pressure to 22,000 volts, but it is not considered advisable, on account of static, to introduce this high pressure into the extensive underground network which has gradually been developed and connected to the 11,000-volt system in Buffalo. On this account another transformation will probably be made at the terminal house in Buffalo, where the overhead line ends and the underground lines begin. This transformation will be from 22,000 volts to 11,000 volts. The power will then, between the dynamos and the consumer's premises, undergo an unusually large number of transformations, which are necessitated by the peculiar conditions of the case, but warranted by the low cost and high efficiency of the large transformers which can be used in work on this scale. In the power house there will be one step-up transformation from 2200 to 22,000 volts, in the terminal house in Buffalo the pressure will be stepped down from 22,000 to 11,000, and at sub-stations in Buffalo it will be further stepped down from 11,000 to 2200 for distribution to consumers who take it in the 25-cycle form. At the premises of these consumers there is a further reduction to 440 volts, 220 volts, or whatever is adopted as most suitable for use under the particular conditions of the installation.

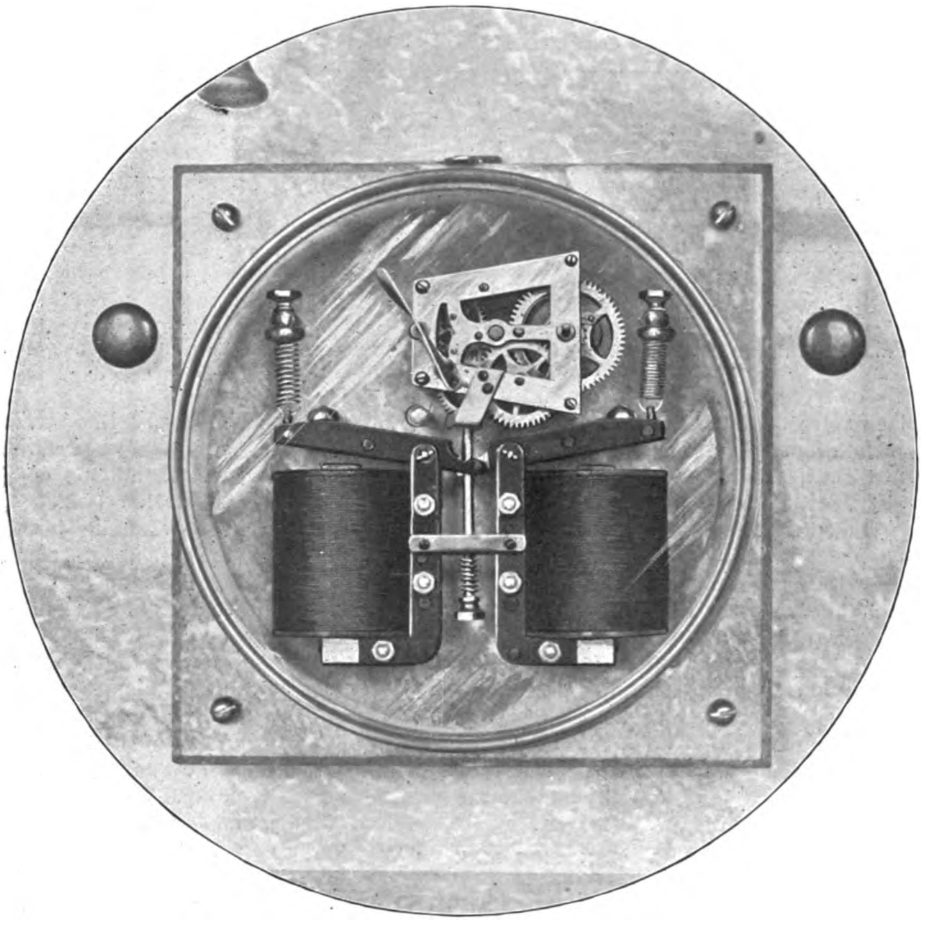


FIG. 28—A VIEW OF ONE OF THE TIME ELEMENT RELAYS. THE TWO COILS ARE CONNECTED RESPECTIVELY WITH CURRENT TRANSFORMERS IN TWO PHASES OF THE LINE. EITHER RELEASES THE CLOCKWORK WHICH, AFTER A PROPER INTERVAL CLOSES A LOCAL CIRCUIT THROUGH THE TRIPPING COILS OF THE BREAKERS.

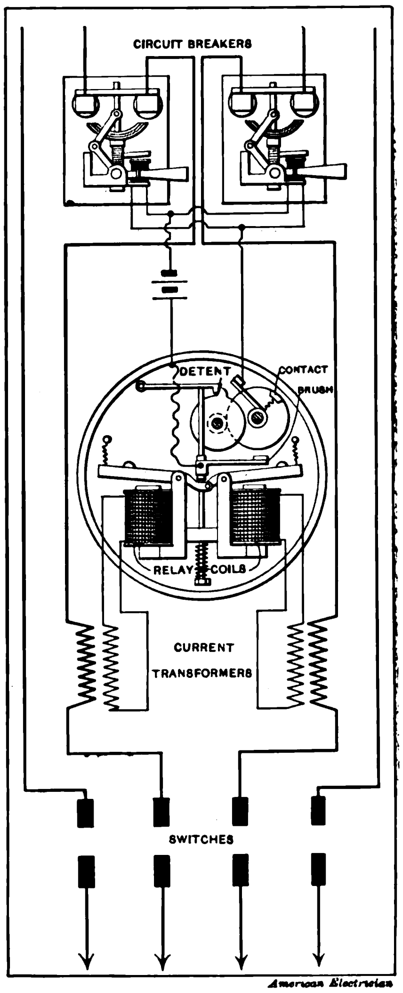


FIG. 29—THE CIRCUITS OF A TIME ELEMENT RELAY CIRCUIT-BREAKING SET.

On account of the large number of extensions and ramifications which this transmission system will undoubtedly possess within a few years, and on account of the enormous amount of power ready to concentrate itself upon any fault and cause serious trouble, the problem of protecting the lines by means of circuit-breaking devices has been studied out with unusual care and developed on an entirely new basis. The problem has been rendered still more difficult owing to the use of a large number of synchronous motors and rotary converters. These machines, when loaded, will fall out of synchronism should the supply be interrupted or the voltage fall seriously during only a few seconds' time. When the supply returns after such a brief interruption the machines are running too slowly to lock in step again, and promptly blow their fuses and stop, causing considerable interference with regular working before the normal condition can be restored. On this account it becomes necessary to maintain at all hazards the continuity of the supply without the slightest wink of an interruption.

The general scheme for doing this in spite of short circuits or broken wires is best explained by reference to the diagrammatic sketch shown in Fig. 27. Here the lines, 1 and 2, are intended to represent respectively two complete three-phase transmission circuits running from the power house at the left to the various centers of distribution. Each sub-station or large consumer of power may be tapped into both these lines, so that in case one fails the other will continue to deliver power. In case a short circuit occurs on one of two lines cross connected in this way at several points, the current will tend, of course, to come over the cross connections, where the sub-stations are tapped out, from one line to the other, thus throwing out the circuit breakers supplying both lines at the generating end. To avoid this contingency there are inserted in the cross connections what are termed reverse-current circuit breakers. These circuit breakers are so designed that when power flows through one of them in the normal direction from the transmission line toward the common connection into the sub-station, the breaker will not operate no matter how heavy the load may be. In case, however, the power tends to flow back through any one of them in the reverse direction from the sub-station connection, into the transmission line, the circuit breaker is immediately affected and opens the circuit. Thus, for instance, if line No. 2 is short circuited at any point, all the reverse-current breakers between it and the sub-station junction points get power flowing through them in the wrong direction, tending to come across from line No. 1 to feed the short. These circuit breakers will open and cut off line No. 2, which will also be cut off at the transmitting end by means of the circuit breaker situated there, leaving No. 1 in service from the generating station to the various sub-stations. Incidentally it might be noted that if any sub-station contains a large storage battery connected with the system through rotary converters or motor generators, and the power is cut off on both lines, leaving this storage battery and its transforming machines loaded with all the other sub-stations, the reverse-current circuit breakers between the storage-battery sub-station and both lines will operate, cutting that station off from both lines and allowing the battery to drive the machines in its own station by means of its stored power. Detailed descriptions of two quite different forms of reverse-current circuit breakers will be given further on in describing the stations of the Cataract Power & Conduit Company and of the Tonawanda Power Company.

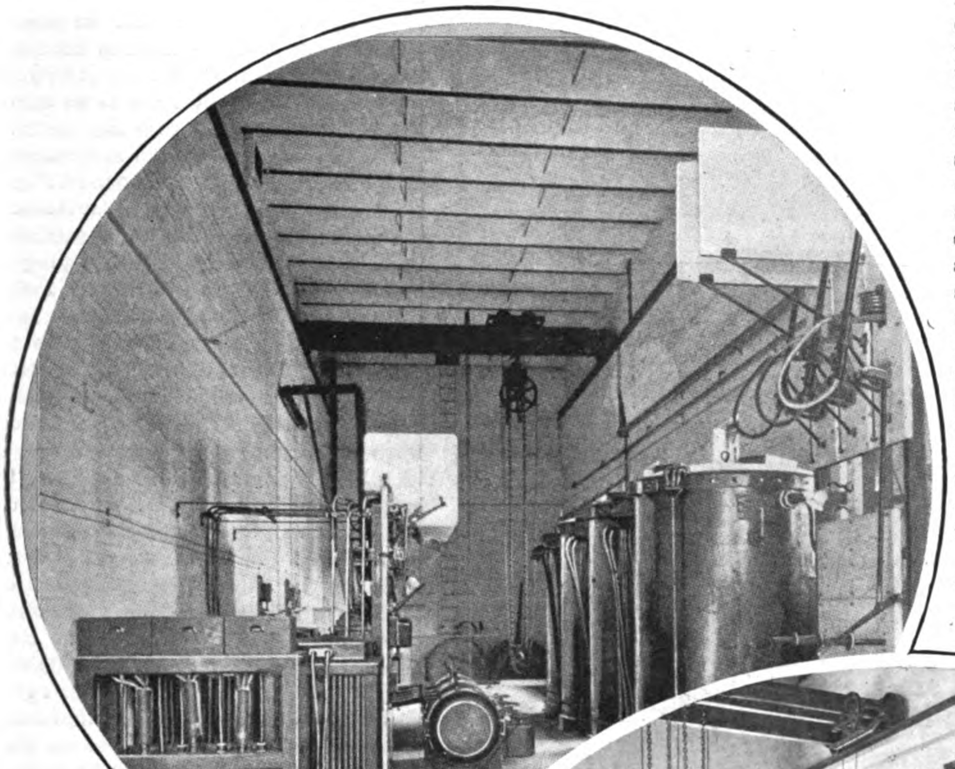


FIG. 30.—THE INTERIOR OF SUB-STATION NO. 2 OF THE CATARACT POWER AND CONDUIT COMPANY, SHOWING THREE 850-KW. 11,000-VOLT TO 2200-VOLT TRANSFORMERS WITH ONE SPARE. THIS SUBSTATION ALSO CONTAINS SWITCHBOARDS AND APPARATUS FOR 15 PER CENT. REGULATION. WHEN FILLED ON PRESENT LINES IT WILL CONTAIN APPARATUS WITH A CAPACITY OF 10,000 H. P. ON A FLOOR AREA OF 2000 SQ. FT.

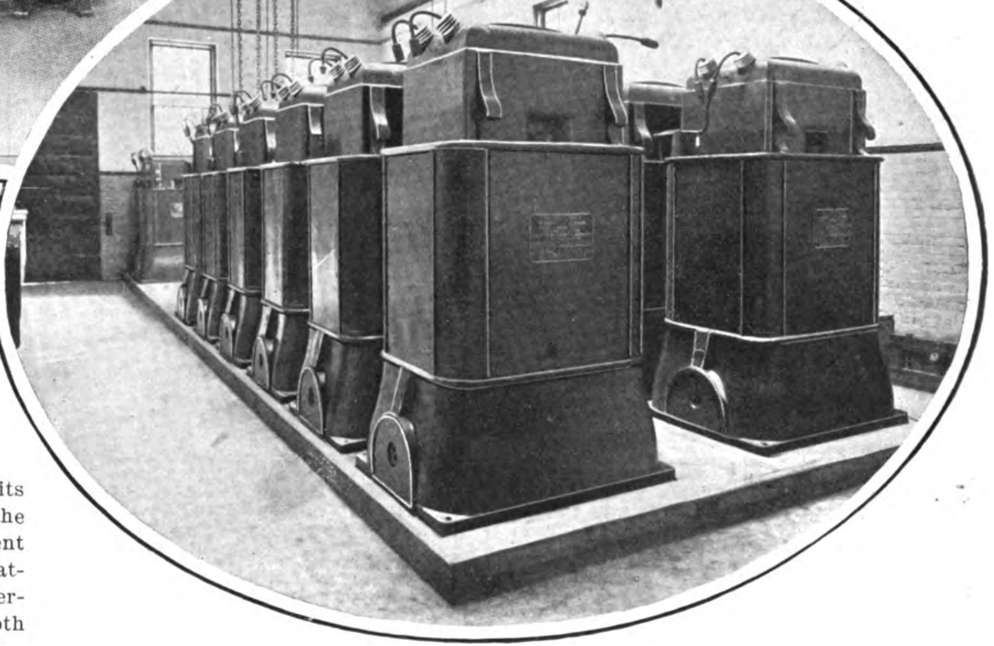
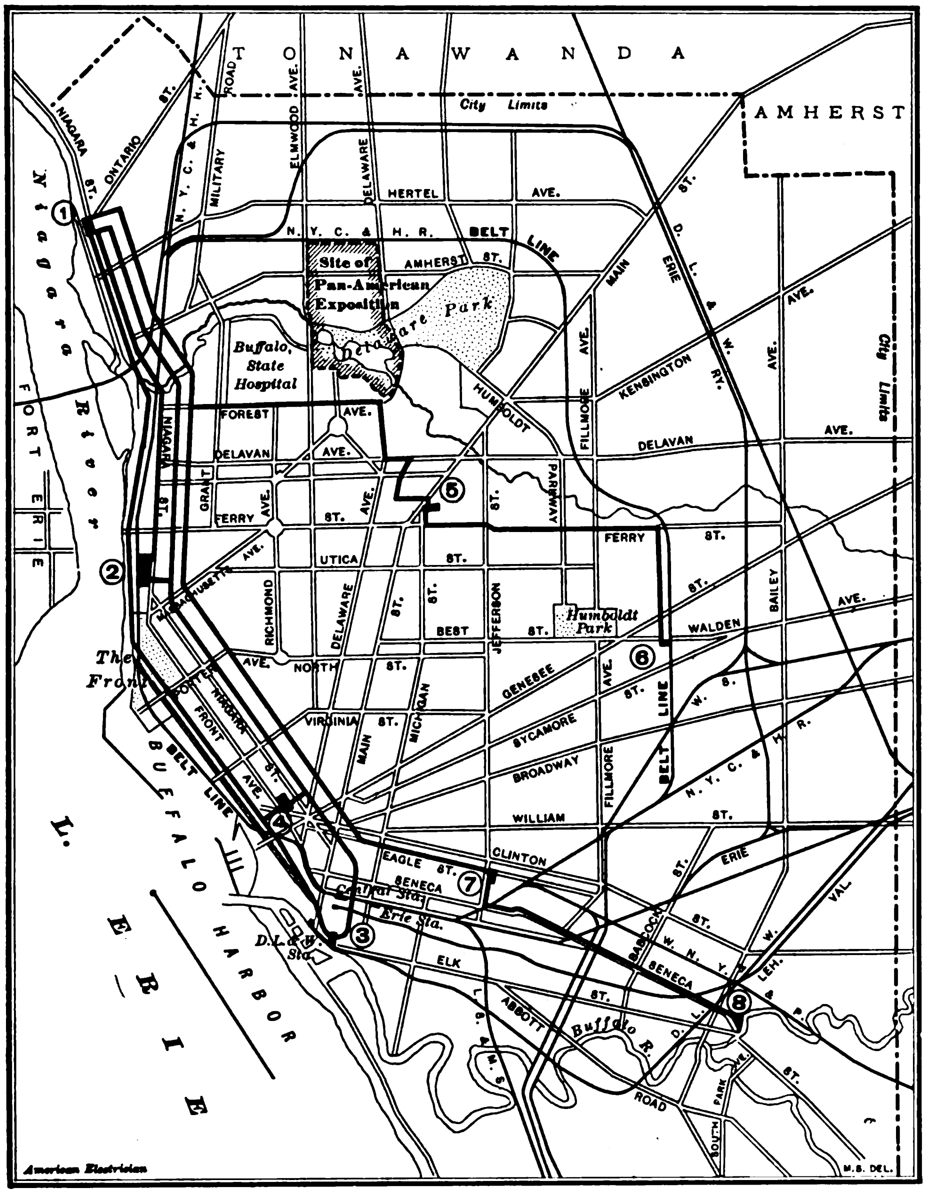


FIG. 31.—A VIEW IN SUB-STATION NO. 3 OF THE CATARACT POWER AND CONDUIT COMPANY. IN THE FOREGROUND ARE TWELVE 250-KW. FORCED DRAFT TRANSFORMERS TAKING POWER AT 11,000 VOLTS 3-PHASE AND DELIVERING 352 VOLTS 3-PHASE TO DRIVE THE CENTRAL STATION OF THE BUFFALO GENERAL ELECTRIC COMPANY. IN THE BACKGROUND ARE FOUR 11,000-VOLT TO 2200-VOLT TRANSFORMERS FOR OTHER CONSUMERS.

The system is further protected by what is known as the time-element feature, which has already been mentioned in connection with the carbide transmission, and is also referred to in the department devoted to patents, on other pages of this issue. At the risk of repetition, the general scheme of the time-element devices will be again pointed out. Referring again to the general diagram of the lines, Fig. 29, it will be seen that the feeders running out from the sub-stations, as well as the sub-stations themselves and the transmission lines in turn supplying them, are all protected by circuit breakers. To prevent a short circuit on a feeder from tripping the circuit breakers operating the whole station, or even the circuit breakers supplying the whole transmission system before the breaker on the feeder can open the circuit and blow out the arc, the time-element feature has been adopted. This feature consists of an arrangement of the parts so that a breaker does not open instantaneously upon the occurrence of a short circuit, but only opens in case a short circuit continues for a certain predetermined and adjustable length of time. This time is so adjusted that the circuit breakers most distant from the generating plant open first—let us say in one second—while those further back toward the plant, and hence covering a greater number of lines or machines, do not operate as quickly, but only after the short lasts three seconds, and those at the plant itself, and covering the whole network, operate most slowly, only after a continuance of the short for perhaps five seconds. Thus, if a short circuit occurs upon a feeder running out from one of the sub-stations the circuit breaker in that feeder operates at once and before the breakers covering the whole sub-station or the breakers in the transmission lines can be tripped. If a short circuit occurs in a sub-station it continues until the breakers protecting the station are tripped, but those protecting the transmission lines, having a longer time interval, remain unaffected.

Two quite distinct forms of time-interval apparatus have been devised and put in service on these lines, one made by the Westinghouse Company and the other by the General Electric Company. The former was described above in connection with the carbide transmission. The latter is in use on the Buffalo transmission line and may be described as follows: The time-element feature is not incorporated in the construction of the circuit breakers themselves, but is brought into their action by means of a relay principle; that is to say, the overload currents, or rather the derived currents from series transformers in the main lines, are not introduced into the breaker tripping coils but are introduced into a separate time-element mechanism, which, in turn, acts as a relay closing a local circuit through the tripping coils and thereby operating the breakers.


TONAWANDA
AMHERST
City Limits
City Limits
NIAGARA ST.
ONTARIO ST.
N. Y. C. & H. R.
ROAD
MILITARY
ELMWOOD AVE.
DELAWARE AVE.
HERTEL AVE.
N. Y. C. & H. R. BELT LINE
Site of Pan-American Exposition
AMHERST ST.
Delaware Park
MAIN ST.
ERIE
D. L. & W. RY.
Niagara River
Buffalo State Hospital
FOREST AVE.
DELAVAN AVE.
HUMBOLDT
FILLMORE AVE.
KENSINGTON AVE.
AVE.
DELAVAN AVE.
FORT ERIE
GRANT
FERRY AVE.
ST.
PARKWAY
FERRY ST.
UTICA ST.
BAILEY AVE.
RICHMOND AVE.
DELAWARE
BEST ST.
JEFFERSON ST.
Humboldt Park
WALDEN AVE.
MASSACHUSETTS AVE.
NORTH ST.
GENESEE ST.
BELT LINE
The Front
PORTER AVE.
NIAGARA ST.
FRONT AVE.
VIRGINIA ST.
MICHIGAN
SYCAMORE
BROADWAY
N. Y. C. & H. R.
WILLIAM ST.
BELT LINE
BUFFALO HARBOR
CLINTON
EAGLE ST.
SENECA
Central Sta.
Erie Sta.
ERIE
BABCOCK ST.
W. N. Y. & P.
LEH. VAL.
D.L.&W. Sta.
ELK
SENECA
ABBOTT ROAD
Buffalo R.
SOUTH PARK AVE.
L. ERIE
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American Electrician
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FIG. 32.—A MAP OF BUFFALO, SHOWING THE LOCATIONS OF THE VARIOUS SUB-STATIONS WHERE NIAGARA POWER IS TRANSFORMED, AND THE SYSTEM OF CABLES SUPPLYING THEM.

No. 1.—Terminal House—end of overhead line and beginning of cables.
No. 2.—Sub-station No. 1—Cataract Power & Conduit Company. Steam power plant, rotary converter and storage battery station of the International Traction Company.
No. 3.—Sub-station No. 2—Cataract Power & Conduit Company. Ohio and Illinois Streets.
No. 4.—Sub-station No. 3—Cataract Power & Conduit Company, and Transforming Central Station Buffalo General Electric Company.
No. 5.—Rotary Sub-station International Traction Company. Maine and Michigan Streets. (Cold Spring Shops.)
No. 6.—Rotary Sub-station International Traction Company. Walden Avenue and Lathrop Street.
No. 7.—Rotary Sub-station International Traction Company. Eagle and Jefferson Streets.
No. 8.—Rotary Sub-station International Traction Company. Seneca and Elk Streets.
Of the four cables supplying these points No. 1 runs to 2 only; No. 2, to 4 and 3; No. 3, to 2, 4 and 3; No. 5, to 5 and 6, with branch to 7 and 8.

One of the breakers is shown in Fig. 33, from which it may be seen that it resembles in form the General Electric railway breaker with the magnetic blow-out attachments removed. The live contacts on the movable part are insulated from the mechanism by a large disc of mica and hard rubber. The breaker only opens a short distance and depends upon a fuse shunted around its contacts to take and destroy the arc which follows this opening.

The time-element device is illustrated in Fig. 27. This consists of a clockwork and two magnets enclosed in a cylindrical case with a glass cover, all of which is mounted on the front of the panel containing the breakers. The two magnets are connected respectively with the secondaries of two series or current transformers in the two phases of a two-phase circuit or two legs of the three-phase circuit to be protected. In case a short circuit occurs on any phase, the current flowing to it must pass through one or the other, or both of these legs, so that there is no necessity of a series transformer and coil for the third leg. If either coil becomes energized by an overload it releases the clockwork of the instrument, and if the short circuit continues, this clockwork closes a local circuit which connects with both the tripping coils of two circuit breakers which open two legs of the circuit to be protected. In case the system is three-phase there is no circuit breaker in the third leg since if two legs are open the load is certain to be thrown off no matter what phase it may be on.

The circuits through the apparatus for protecting one line are shown in Fig. 28 from which an idea may be obtained of the method of restoring the apparatus to its original position without tripping the breaker, provided an overload or a short circuit is removed before its time interval has passed. The rod which is raised by the movement of the magnet armatures is mechanically attached to a brush bearing on a wheel turned by the clockwork and carrying a contact strip. As long as the short circuit continues, this brush is held up against the wheel so that when the strip is rotated until it makes contact with the brush, a local circuit is closed to the tripping coils of the circuit breakers. If, however, the short circuit or overload is removed while the mechanism is under way, the brush falls away from the contact wheel, the detent by means of which the clockwork is released falls to its normal position, and the clockwork comes to rest without closing the circuit through the tripping coils.

In the arrangement shown, the tripping coils are energized by means of a primary battery, but this can be, and is in certain instances on the Niagara system, replaced by a potential transformer when the fear is not entertained that a short circuit may pull down the voltage to such an extent that the potential transformer would not energize the tripping coils. In order to make the magnets of the time-element mechanism allow their armatures to return to normal positions when the overload is thrown off, and in order to prevent the armatures from being retained down by normal loads, the movement of these armatures must be small compared with the total length of the air gap, otherwise the armatures will be held to the poles of the magnets by much smaller currents than those necessary to pull them down.

It will be seen from this description that the whole arrangement differs considerably from that adopted by the Westinghouse Company for the same purpose and described above under the carbide transmission, since the Westinghouse instruments involve mechanical connection between the breakers and time-element mechanism, which latter is constructed on the foucault-current disc principle instead of the fan-brake principle used in the General Electric mechanism just described.

THE WORK OF THE CATARACT POWER AND CONDUIT COMPANY.

The work of distributing, transforming

and selling the power transmitted by the Niagara Falls Power Company to Buffalo is carried on by an associated corporation known as the Cataract Power & Conduit Company. This company assumes control over the transmission line where it enters the Buffalo city limits, and handles the power from that point to the consumer's premises. The property of this company consists altogether of a distributing network, largely underground, and several sub-stations containing transformers, switchboards and regulating apparatus, but with no running machinery except small auxiliary apparatus such as blowers.

The company's work is so largely of a concealed nature that but few realize the extent of the underground network that is already distributing 25-cycle power throughout the city of Buffalo. Beginning at the city line, the company operates a section of the overhead pole line running in from the city limits 3740 feet to a new terminal house, where the overhead pole line ends and the underground cables begin. This terminal house contains simply lightning arresters and switchboards for cutting out either one of the overhead transmission lines or any one of the various cables that start from it. The cables from this point to the various sub-stations are, of course, operated at 11,000 volts. They are at present four in number and run to the points indicated on the map of Buffalo reproduced in Fig. 32. These 11,000-volt cables aggregate a total length of 151,000 feet. They are three-conductor cables, mostly of sizes No. 000 and No. 1.

In addition the company operates about 20,000 feet of three-conductor cable on its 2200-volt distribution lines from the sub-stations to consumer's premises, as well as some 27,000 feet of overhead pole line on the 2200-volt system. For its underground cables the company now has about 65,000 feet of conduit, nearly all Camp vitrified tile with concrete manholes. This conduit aggregates about 825,000 duct feet, in addition to which the company occupies other conduits in common with the Buffalo General Electric Company and has some of its cables drawn into conduits belonging to the International Traction Company. With both these companies the Cataract Power & Conduit Company is associated through its delivery of power for their use.

Referring again to the map, it will be seen that three cables are used to supply the three sub-stations of the Cataract Power & Conduit Company, one cable running to sub-station No. 1 only, one other to sub-stations Nos. 2 and 3, and the other to all three sub-stations. The fourth, which was only drawn in during the last year, is used for supplying four new rotary converter sub-stations of the International Traction Company, located at points designated by Figs. 5, 6, 7 and 8 on the map. This cable forks to two branches, one running to two of these sub-stations and the other to the other two. The total length of the cable is some 14 miles. This long cable is of the Habirshaw make, manufactured by the India Rubber & Gutta Percha Insulating Company, Glenwood Works, Yonkers, N. Y.

On account of its length this cable will be divided into sections by junction boxes located in manholes. Each of these 11,000-volt junction boxes will consist of a small marble panel carrying three switches mounted on hard-rubber bushings and separated by barriers; the whole arrangement being similar to the switches used in the sub-station work. This little switchboard will be enclosed in a cast-iron box with removable covers both front and back for reaching either the switches themselves or the back connections. The covers will be bolted on water-tight rubber gaskets.

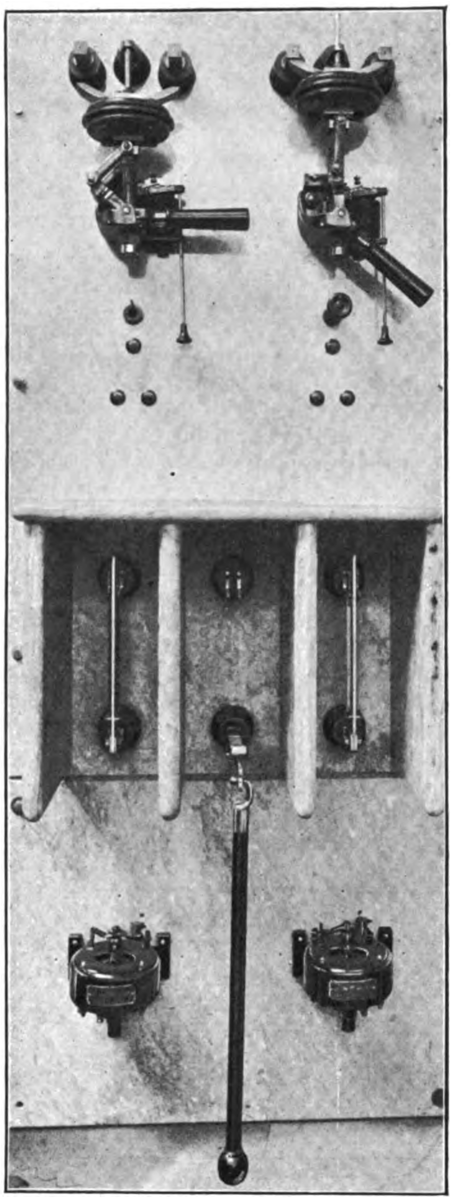


FIG. 33.—AN 11,000-VOLT 3-PHASE SWITCH AND REVERSE-CURRENT CIRCUIT BREAKER PANEL. THE BREAKERS ARE PROTECTED BY SHUNT FUSES AND ARE OPERATED BY THE REVERSE CURRENT RELAYS, CONSISTING OF DIRECT-CURRENT FAN MOTORS SHOWN ON THE SUBBASE OF THE PANEL.

The general scheme of this company's distribution comprehends transformation in sub-stations from the line pressure of 11,000 volts three phase to 2200 volts three phase with distribution at this pressure to consumer's premises, at which points the pressure is again reduced to that required by the apparatus driven. In the case of very large consumers this scheme is departed from by locating the sub-stations immediately adjacent to the premises and transforming direct from the transmission line pressure to the voltage desired by the consumer. For instance, sub-station No. 1, indicated at point No. 2 on the map, is located in the structure of the International Traction Company's famous steam-power plant on Niagara Street. In this sub-station 2000 h. p. is transformed from 11,000 volts to 360 volts three phase, at which pressure it is taken by the railway company's rotary converters. The station also contains 11,000-volt to 2200-volt transformers for supplying motor loads in the vicinity.

Sub-station No. 2 (see Fig. 30) is located down in the dock district in the midst of large grain elevators, ship yards, etc. Power is transformed at this point only to 2200 volts three phase, but with arrangements for a considerable range of voltage by means of induction regulators or boosters. These were provided on account of the heavy induction-motor load taken off from this station and the drop liable to be caused by the lagging currents of such a load.

Sub-station No. 3 (see Fig. 31) is a wing of the Buffalo General Electric Company's central station, which is driven entirely by means of Niagara power. The Buffalo General Electric Company takes all its power at 352 volts three phase on account of this pressure being suitable for the 500-volt rotaries of its power service, and also on account of the fact that this pressure is a convenient one for the many synchronous motors driving arc and other central station dynamos. Three hundred and fifty-two volts is high enough to avoid excessive cost of copper in the station distribution and low enough to avoid difficulties in the insulation of motor windings or physical danger in operation. On this account sub-station No. 3 of the Cataract Power & Conduit Company delivers most of its power at 352 volts three phase, something over 3000 h. p. being demanded by the Buffalo General Electric Company at times of heaviest loads. The sub-station also contains 11,000-volt to 2200-volt transformers for large motor loads in adjacent territory, small motor loads being carried by 500-volt d. c. motors run from the Buffalo General Electric Company's power circuits.

The power taken in by the four new rotary converter sub-stations of the International Traction Company is not transformed by the Cataract Power & Conduit Company, the traction company taking the power in the 11,000-volt form and doing its own transformation.

There are now connected to the circuits of the Cataract Power & Conduit Company alternating-current motors or rotary converters with an aggregate capacity of 13,000 h. p. Owing to the present lack of sufficient generating equipment at Niagara Falls to meet the increasing demand, the Cataract Power & Conduit Company has been limited—as was mentioned above—to about 10,000 h. p. On this account and until additional installation at the Falls, now under construction, is completed, the company will be unable to take on new loads except small ones with peaks not coinciding with those of its daily load curve. The Buffalo General Electric Company alone has contracted for 3000 h. p., and the International Traction Company, as soon as its new rotary stations are finished, will take 5000 h. p.

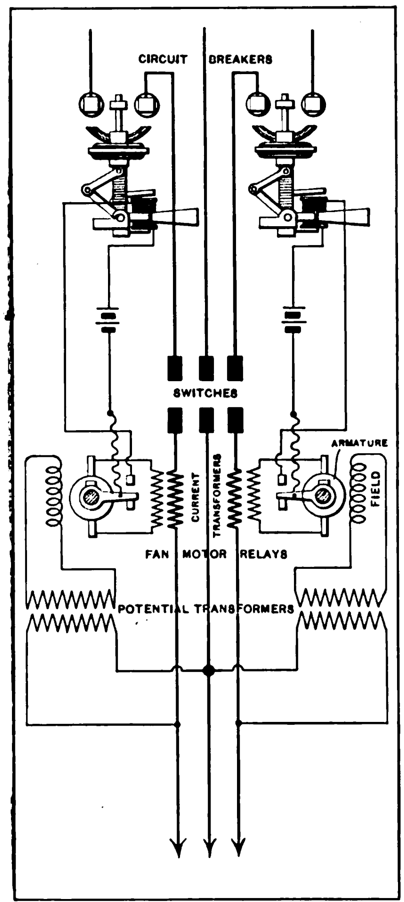


FIG. 34.—THE CIRCUITS OF A REVERSE-CURRENT CIRCUIT BREAKER SET, SHOWING HOW A DIRECT CURRENT MOTOR IS USED WITH ALTERNATING CURRENTS TO DISTINGUISH BETWEEN POWER PASSING IN ONE DIRECTION AND POWER PASSING IN THE OTHER DIRECTION IN THE LINK.

The other loads are comparatively small, but by no means insignificant either in size or in number. Two large grain elevators are supplied from substation No. 2, one requiring 1000 h. p. The Union Dry Dock Company operates extensive machine shops by means of induction motors. These shops are unique in that individual motors, one for each machine, are used, probably the first instance of individualization of alternating-current motors to any considerable extent in this country. Owing to the high speed of induction motors they are not direct geared to the tools, but are belted. In the yard of the same company the polyphase currents drive a mammoth crane serving the building berths. This crane, the individual motors in the shop, and the motors of the elevators mentioned above, are a standing refutation of all arguments against the use of alternating-current motors on account of their alleged inability to drive loads requiring high starting torques or variable speeds.

A few figures as to the efficiency of the transformation and transmission from Niagara Falls to Buffalo may be of interest. The total loss between the primary or 2200-volt side of the step-up transformers at Niagara Falls and the secondary or 352-volt side of the step-down transformers in sub-station No. 3 in Buffalo amounts to about 25 per cent. of the power delivered throughout the entire day. This is a transmission of 28 miles with two transformations. The efficiency is maintained at a high point under light loads by cutting out step-up and step-down transformers and taking all advantage possible of the increased efficiency of the line at low loads.

In the substations of this company, Nos. 1 and 2, we find the first reverse-current circuit breakers, the general purpose and principle of which were outlined above in the general discussion of the protection of the transmission line. A panel containing a complete equipment of these breakers is illustrated in Fig. 33. At the top of the panel may be seen the breakers themselves, two in number, for two legs of the three-phase circuit. They open but a short distance as the right-hand one indicates, the arc being taken and blown out by means of a shunt fuse exactly like that used with similar breakers fitted with the time-element feature described above in connection with the Niagara Falls end of the transmission line.

The tripping coils of the breakers are connected with relays which consist simply of G. E. fan motors. The two motors may be seen on the sub-base of the panel. These fan motors are provided to distinguish between power going through the circuit in one direction and power going through in the other direction in order to operate the breakers only when the direction of transference of power reverses. Obviously in alternating-current work the current itself is constantly reversing and no polarized apparatus can be used to distinguish between a flow of current in one direction and that in the other. The fan motors have their fields connected to potential transformers, giving them a constant and strong alternating magnetization. The armatures are connected through the brushes with series or current transformers as indicated in the general diagram of circuits, Fig. 34.

The reaction of the current in the field upon that in the armature of one of these fan motors sets up a torque in one direction on the motor shaft because the currents in both armature and field reverse simultaneously. If, however, the direction of flow of power in the main circuit reverses, the armature of the fan motor gets what might be called a positive current while its field is getting a negative, whereas formerly both armature and field received positive currents simultaneously; the torque of the armature is reversed and a crank mounted on the motor shaft rotates from a back stop to a front contact closing a local circuit through the tripping coil of the circuit breaker. This local circuit may be, and is in most cases, excited by a potential transformer, or it may be excited by means of a battery, as indicated for simplicity's sake, in the diagram. The local circuit passes through a contact on the breaker (not shown in the diagram) designed to cut off the battery power as soon as the breaker is tripped.

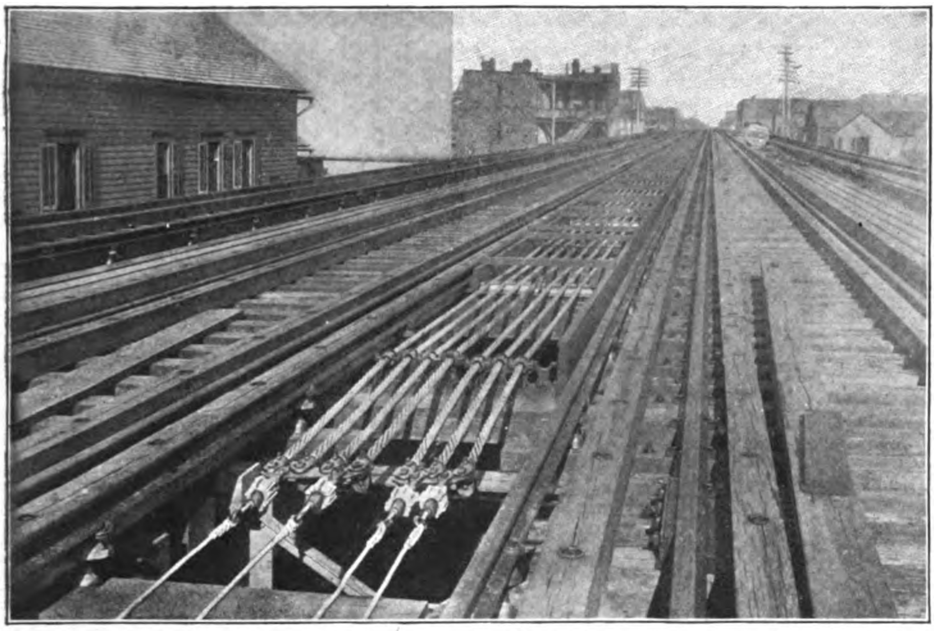
It is of course desirable that there should be no difference of phase between the currents in the armature and the field of the fan motor when the load is non-inductive; then a considerable lag or lead of the load will not cause a reversal of the torque. This can be realized in several ways well known in alternating-current work, such, for example, as connecting in Y the primaries of the potential transformers supplying the fields of the fan motors; or the self-induction of the motor field may be depended upon. In actual practice at Niagara a small three-phase transformer is used, so built and connected that proper phase relation is obtained.

In future issues of the American Electrician the work of the Buffalo General Electric Company, the International Traction Company and the Tonawanda Power Company will be described.

Aluminum Feeders on the Northwestern Elevated Railroad, Chicago.

One of the foremost intramural transportation systems of the country, the new Northwestern Elevated Railroad of Chicago, has adopted aluminum feeders for its extensive electric system. Over 24 miles of single track are being equipped for heavy traffic by means of electrical motors, 150,000 pounds of the new rival of copper having been purchased for the purpose. As something over one-half of this large amount of aluminum has already been put in place, it is now possible to observe on the installation the methods used in handling the wire and the manner in which some of the more evident difficulties in its use are overcome.

The Northwestern Elevated Railroad is the last to approach completion of the great transportation projects fathered by Mr. Charles T. Yerkes. In many respects this latest child of Mr. Yerkes is the most remarkable. From the time the first drawing was made, the order has been in force to make the new road the most perfect piece of transportation property that money can buy. Consequently both in design and execution, every part and appurtenance of the great structure represents the latest and most advanced ideas in rapid intramural transit. It is under this extremely favorable condition that the experiment of using aluminum feeders is being tried.



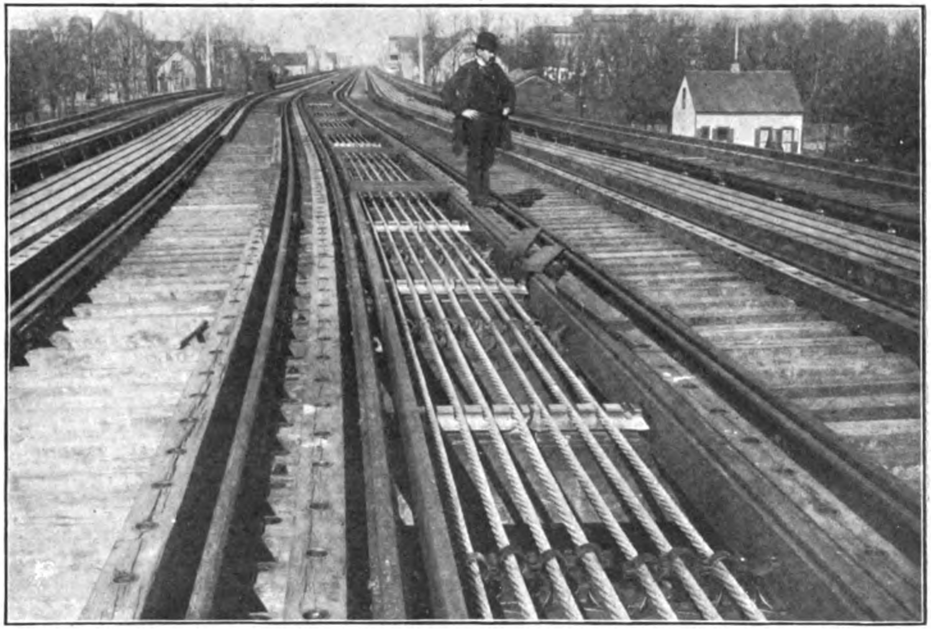
THE TERMINALS OF THE ALUMINUM FEEDERS.

The ends of the feeders are soldered into copper connectors with depending lugs to which copper feeders, rising from the ground below, will be soldered. The connectors are bolted to cross bars to which are also fastened steel cables through strain insulators.

Briefly, the Northwestern Elevated Railroad consists of 5½ miles of four-track elevated structure and one mile of double-track structure. The double-track structure extends from the junction with the union elevated loop in the heart of the main business district of Chicago, along Wells and Franklin Streets to Chicago Avenue. From that point to the terminal at Wilson and Evanston Avenues, the four-track structure stands on its own right of way, secured by purchase. The general direction is northwesterly from the business district. The terminus at Wilson Avenue is close beside the tracks of the Chicago, Milwaukee and St. Paul Railroad's Evanston branch, and the Evanston Avenue trolley line of the Chicago Consolidated Traction Company. The Milwaukee and St. Paul road is now trying to secure permission to change the motive power on the Evanston branch to electricity, in which event its cars will probably use the Northwestern elevated's structure into the center of the city. As the northern portion of this steam line's tracks are now being used by the Chicago and Milwaukee Electric Railway, a complete electric service from the heart of Chicago to Milwaukee seems eventually assured.

Throughout the four-track structures of the Northwestern Elevated Railroad an express and local service will be maintained. The express service will be fast, with stops a mile apart. The local service will be slower, with stations every 1500 feet. At the express stops the transfer from one set of trains to the other will be made by merely walking across a platform. The two-track structure and its two stations will be used alike by both sets of trains.

The well-known third-rail system has been installed throughout the Northwestern elevated railroad. Equipment consisting of heavy motor cars and lighter trail cars will be employed, of a general appearance closely resembling the equipment in use on the Metropolitan and Lake Street elevated roads in Chicago. The power house for the line is located at Southport and Fullerton Avenues, between 3000 and 4000 feet from the structure.

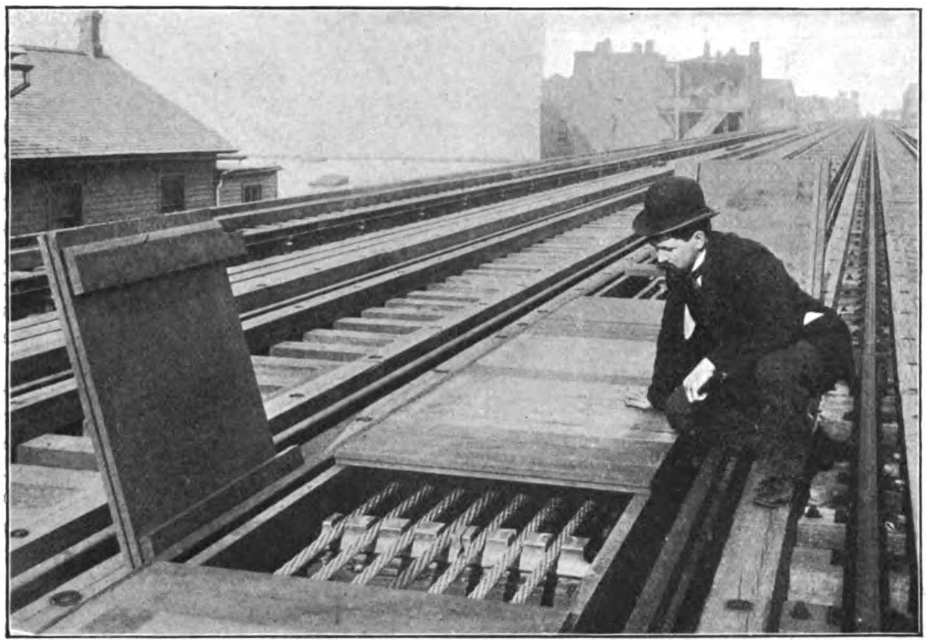


A VIEW OF THE CURVE CONSTRUCTION SHOWING THE USE OF SPLIT-SPOOL INSULATORS AND VITRIFIED CLAY SUPPORTS

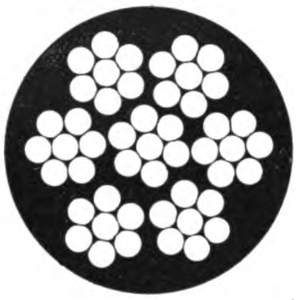
As may be well guessed, the reason why aluminum was decided on for the feeder system of the Northwestern Elevated Railroad over copper was its greater cheapness, with equal degree of efficiency. Electrical Engineer J. R. Chapman reasoned that for the purposes of the road aluminum was equal to, if not superior to copper, and was considerably cheaper. Hence its use. In March, 1899, when the question came up, Mr. Chapman figured that 48 pounds of aluminum of the conductivity offered to the road was equal in current-carrying power to 100 pounds of copper of the ordinary 98 per cent. conductivity. As copper at that time was quoted in the market at 18 cents a pound, he figured that he could afford to give 36½ cents a pound for aluminum. But aluminum was selling then close to 30 cents a pound, so Mr. Chapman decided to use it. He made a deal a little better than the figure given, and saved his company something over $8,000 by the substitution of the white metal.

The aluminum bought for the Northwestern Elevated Railroad is entirely for the feeder system, and is confined to the portion running along the structure. From the power house to the structure the current is transmitted by lead-covered copper cables, which run along Dunning Street in vitrified clay conduits. Over 10,000,000 c. m. in copper cables are carried in the conduit. The 40 ducts of the conduits also carry 8 1,000,000-c. m. tinned bare copper return cables, which connect the structure with the negative side of the switchboard. At the junction of Dunning Street and the Northwestern elevated line six manholes are located, out of each of which six three-inch wrought-iron pipes run up pillars of the structure. The 36 pipes carry the lead-covered copper up to its point of junction with the aluminum, and also bring back the return cables attached to the iron work of the structure. In this connection it may be noted that the entire structure is used as a return, each rail of the track being bonded to the iron work with a flexible bond, no bonds being used at joints except in the case of the trolley rails.

The aluminum feeders run from the point of junction with the underground system to the taps for the trolley rails on all parts of the structure. They consist of bare stranded cables of three sizes, 1,365,000 c. m., 1,050,000 c. m. and 785,000 c. m., though there is but little of the last size used. The largest size is, roughly speaking, about 1½ inches in diameter. It is "cable laid," consisting of 49 separate strands, and is astonishingly strong for its weight. The wire is handled in large spools of the size used for large copper cables. The spools, however, instead of weighing 3800 to 4600 pounds, as in the case of copper, only weigh about 1600 pounds. The advantages in ease and cheapness of handling are evident.



A SECTION OF THE FINISHED FEEDER BOX SHOWING TWO OF THE TRAP DOORS OVER THE INSULATING SUPPORTS OPEN.



A FULL SIZE CROSS SECTION OF THE 1,050,000-C. M. CABLE.

These bare aluminum cables are laid in a feeder box built of pine, along the center of the structure. There are in all about 24,000 feet of the boxing, of varying width, according to the number of cables carried. The largest number of cables in the boxing is eight, and the smallest two. The track is divided into five sections, each getting its quota of cables. Besides the aluminum feeders the boxing also carries a 30-pair telephone cable for communication with the stations, and a 350,000-c. m. insulated copper cable for lighting purposes.

The aluminum cables are laid in the feeder box on vitrified clay insulators placed on cross ties every 9 feet. Every twentieth set of supports consists of Anderson split-spool insulators, which are clamped tight to the wire, and give the needed strain. On the curves the vitrified clay supports and the iron chairs alternate. After the wires are put in place in the boxing the latter is covered over and forms a footway in the center of the structure. Loose covers or lids are left at each insulator for access in case of repairs or changes. It is evident that this method places practically no reliance on the tensile strength of the aluminum cables, since they are supported every 9 feet and anchored every 180 feet. Questions of insulation for the cables are also avoided.

The ends of the aluminum cables are anchored in a singular and highly effective manner. To the cable are soldered large copper connectors, which, in turn, are attached to Brooklyn strain insulators made for the purpose. These latter are held by heavy bare iron wires attached to eye bolts in wooden cross pieces. The copper connectors have another opening for copper wire of a carrying capacity equal to the aluminum. This arrangement is used where the underground wires connect with the aluminum feeders on the structure, and also at all special work and points where the path of the feeder boxing is interrupted. In such cases as the latter the ends of the aluminum cables are anchored, and insulated copper wire is run down under the tracks and past the obstruction, being connected with the ends of the aluminum cables again beyond.

This scheme for anchoring the ends of the cables also exemplifies how the cables are spliced. For the successful carrying out of all splicing operations, which have always been considered one of the most difficult points in the electrical use of aluminum, a remarkably simple method has been adopted. A plain copper connector of the ordinary type receives the two ends of the wire, which are then soldered fast into the connector. The only difficult point is the question of solder. This has been successfully solved by a machinist who works for the Northwestern Elevated Railroad, H. L. Gronimus by name. After considerable experimentation he has found a composition of metals which will not only successfully solder aluminum to copper, but also aluminum to aluminum. Naturally he declines to state the materials in his solder, but its results on the Northwestern Elevated show the value of the composition.

ONE OF THE THIRD RAILS SHOWING THE COPPER TAPS RUNNING TO THE ALUMINUM FEEDERS IN THE MAIN BOXING AND SHOWING ALSO A BOND AND THE INSULATING CHAIRS.

Connectors are also used in making taps from the aluminum feeder cables to the trolley rail. This trolley rail is raised up on double petticoated insulators above a wooden string piece, the joints being well bonded by flexible bonds. Taps run from the feeder cables to it every 1500 to 2000 feet. Either one or two strands of 0000 insulated copper cables are used for the taps, except at the ends of the feeders, where a tap of practically the same carrying capacity as the cable is used. These taps are soldered to copper clamps which are tinned and then screwed tight around the feeder cables. The clamps are not soldered to the aluminum, pressure alone being relied on for a good contact. The junctions with the cables are covered with tar or pitch paint. At the other end the taps are soldered to copper plates, which are riveted to the trolley rails.

Of the general character of the electrical work on the Northwestern Elevated Railroad no better idea can be given than that obtained from the statement of E. J. Ward, the superintendent in charge of the electrical construction, who states:

"The electrical work on the Northwestern Elevated Railroad is far superior to any I have ever seen. Our orders have been to neglect no opportunity to improve on the methods and material used on the other roads. The result has been to produce what I have no doubt is the best piece of electrical elevated railroad construction of the world."

Under these auspices the trial of aluminum conductors on the Northwestern Elevated Railroad ought to give most valuable results. Mr. Chapman is keenly interested in the experiment—if experiment it can be called—and expects to prove much to the credit or disadvantage of the new substitute for copper. Among other things he intends putting a piece of bare aluminum cable in circuit with one of the return copper cables and locating the piece in the worst man hole in his underground system. From this he expects interesting comparisons with copper in another field.

◆

THE WATERSIDE GENERATING STATION OF THE NEW YORK EDISON COMPANY.

Since the control of the Edison Electric Illuminating Company of New York City passed into the hands of the Whitney syndicate the plans for the mammoth central generating station which were outlined in the last annual report of the company, as noted in the American Electrician of April, '99, have been carefully revised and considerably changed in detail, and the work is now under way on the foundations of the new installation.

The plant will be, as originally planned, located on the East River between 38th and 39th Streets. The boiler room will be double-decked and filled with 56 boilers of 600 h.p. each, on a conservative rating, giving a steam-generating capacity equivalent of 33,600 h.p. on the centennial rating. These boilers will discharge their gases into four steel stacks 17 feet in diameter inside the brick lining. Coal will be stored in bunkers capable of holding 10,000 tons. The boilers will be provided with superheating equipments designed to heat the steam to a temperature of 550 degrees F.

The operating room will contain 16 generating units in two rows, one to each side of the room, each unit consisting of a three-cylinder three-crank triple expansion vertical engine direct coupled to a three-phase alternator. The alternators will be on the end of the engine shafts toward the center of the room so that to either side of the central aisle there will be a row of dynamos with the engines beyond them toward the walls. Each engine will be capable of giving 5000 or 6000 h.p. economically and of running up to 9000, or even 10,000 h.p. should this amount of power be demanded. The engines will be made by the Westinghouse Machine Company.

The dynamos will be rated at 3500 kw. each, but capable of delivering 4300 kw., continuously for three hours with a rise of temperature of not over 50 degrees C. They will be 40-pole machines, running at 75 r.p.m. and consequently giving 25-cycle current. They will generate directly the line pressure of 6600 volts. In order to certainly eliminate all trouble in parallel running the machines will be fitted with unusually heavy fly wheels and will have special governors designed to have a time element, i. e., to be sluggish in their action so that in case the machines commence to hunt, the governors will not be sufficiently sensitive to respond to the hunting and throw the valve gear so as to increase it. The engines will be guaranteed to vary in speed throughout the stroke less than 1/10 of a degree from true uniformity of revolution. The dynamos will have an efficiency of about 97 per cent. and regulation of 8 per cent.

To break the large powers of these powerful and close-regulation machines, special switches will be provided capable of handling easily the rated loads, which amount per machine to 250 amperes per phase at the economical rating and 400 at the overload rating. This switch will be operated by electro-pneumatic means and will make the final break of the circuit under oil, being in these respects similar to some switches already used in Brooklyn and Chicago Edison service, previously noted in these columns, but they will differ from these in many respects, particularly in the use of main and auxiliary contacts in shunt with each other. The main, or low-resistance contacts, will be in air and will be broken before the auxiliary contacts, which will be in oil. Current for exciting purposes of these large generators will be derived from direct-current generators driven by induction motors and running in parallel with a storage battery to give steadiness. The d.c. network will provide a reserve source of supply.

The distribution will be over three-conductor cables, of two sizes, with conductors having respectively cross-sections of 200,000 and 250,000 c.m. The cables will be of the triple-conductor type, with so-called "split" rubber insulation, i. e., each conductor will be surrounded by rubber having a thickness of 5/32 of an inch, and the three insulated conductors so formed will be further surrounded by rubber 5/32 of an inch thick beneath the lead sheath. This will give 5/16 inch of rubber between any two of the conductors or between any conductor and the lead.

Each sub-station will be supplied by cables running over two independent routes, so that should one entire conduit be burned out, the service would not be discontinued. The sub-stations will contain rotaries having a rated capacity of 500 kw. each, with a heavy overload capacity, and delivering a direct-current pressure of nominally 270 volts, but variable by means of induction regulators between 240 and 300 volts, so that they may be used directly upon the network or to charge storage batteries. The neutral conductor will be taken into the center of the batteries and also into the center of the a.c. low-tension windings connected to the rotaries. The efficiency of these rotaries will be about 95 per cent.

This system will gradually pick up the loads now carried by the Edison Company's inland steam and annex stations as well as those of several associated companies, all the companies operating in the Borough of Manhattan, with the exception of the United Electric Light & Power Company, being associated under the ownership of the New York Heat, Light & Power Company.

The Edison Company has recently extended its three-wire service into a residence district of New York City on the west side of Central Park, known as the upper West Side, which has previously been supplied entirely by alternating service. In this extension the use of Edison tubes for feeders and mains has been abandoned, the new conductors—both feeders and mains—being entirely lead-covered cables drawn into conduits. The mains are single-conductor cables with cross-sections of 200,000 or 350,000 c.m., three of these cables being drawn into one 3-inch duct.

The feeders are quite a novelty in this country, being two-conductor concentrics. The central core is a cable with a cross-section of 1,000,000 c.m., which is surrounded by paper insulation 5/32 of an inch in thickness; around this, again, is an annular cable also with a cross-section of 1,000,000 c.m., into which are woven three pressure wires. This is, in turn, surrounded by 5/32-inch paper within the lead sheath. The neutral is carried by single-conductor trunk feeders, i. e., the neutrals corresponding to many different plus and minus concentric feeders, are tied together and brought into the station through a heavy trunk, filling a 3-inch duct. The purpose of this unusual arrangement is to obtain maximum conducting capacity possible in the ducts in order to reduce the conduit rentals, which are quite high in New York City.

THE COST OF ARC LIGHTING.*

BY H. H. WAIT.

The tables in this paper, giving the comparative first cost and operating expenses of various arc-lighting systems, were originally compiled in a rough form some little time ago in order to determine whether it would pay to build a large direct-current arc machine suitable for direct driving by moderate-speed engines.

It is hoped that the tables are in such form that an engineer can pick out several systems to compare for any given plant and avoid the labor of going through the entire subject.

The vital question in comparing alternating and direct-current systems is the relative amount of power consumed for the same amount of light. There is a great diversity of opinion on this subject and good authority can be found for all sorts of factors.

In the tables the different types of lamps have been given the following ratings for the sake of comparison:

D. C. open arc.......	450 watts at arc	2000 c.p.
D. C. enclosed arc..	450 watts at arc	1500 c.p.
A. C. enclosed arc..	450 watts at arc	1150 c.p.
A. C. enclosed arc..	400 watts at arc	950 c.p.
D. C. open arc.......	300 watts at arc	1200 c.p.
D. C. enclosed arc..	300 watts at arc	900 c.p.

It is unfortunate that the 2000 and 1200-c. p. ratings of 450 and 300 watts, respectively, adopted by most plants, do not refer to the watts at the arc, but seem to include some small loss in the mechanism. It has been thought advisable for the sake of definite comparison to give these ratings to open arcs, the watts being taken at the arc itself and corrections being made for the relative efficiency of the mechanism for different types of lamp. To arrive at an equitable figure for comparing the enclosed a. c. and d. c. lamps with the open arcs, resort has been made to an average of the information at hand on this subject. This average showed that the same watts give about 75 per cent. as much light in an enclosed as in an open arc.

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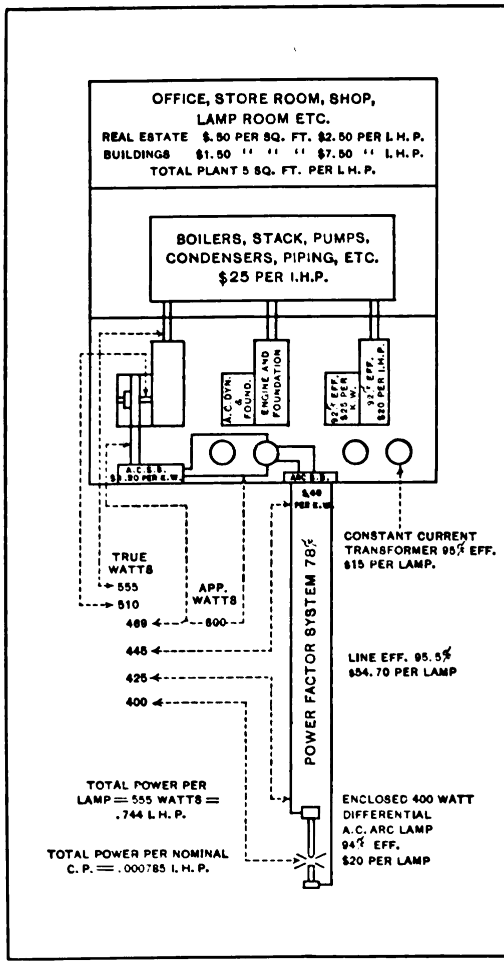
* From a paper read before the American Institute of Electrical Engineers Dec. 17, 1899.



OFFICE, STORE ROOM, SHOP, LAMP ROOM ETC.
REAL ESTATE $.50 PER SQ. FT. $2.50 PER I. H. P.
BUILDINGS $1.50 " " " $7.50 " I. H. P.
TOTAL PLANT 5 SQ. FT. PER I. H. P.
BOILERS, STACK, PUMPS, CONDENSERS, PIPING, ETC. $25 PER I.H.P.
A.C.DYN. & FOUND.
ENGINE AND FOUNDATION
92% EFF. $25 PER K.W.
92% EFF. $20 PER I.H.P.
A.C.S.B. $1.20 PER K.W.
ARC S.B.
$.40 PER K.W.
TRUE WATTS
555
510
APP. WATTS
469
600
445
425
400
POWER FACTOR SYSTEM 78%
CONSTANT CURRENT TRANSFORMER 95% EFF. $15 PER LAMP.
LINE EFF. 95.5% $54.70 PER LAMP
TOTAL POWER PER LAMP = 555 WATTS = .744 I. H. P.
TOTAL POWER PER NOMINAL C. P. = .000785 I. H. P.
ENCLOSED 400 WATT DIFFERENTIAL A.C. ARC LAMP 94% EFF. $20 PER LAMP

FIG. 1.—ALTERNATING CONSTANT CURRENT TRANSFORMER.

400-WATT ENCLOSED ARC.

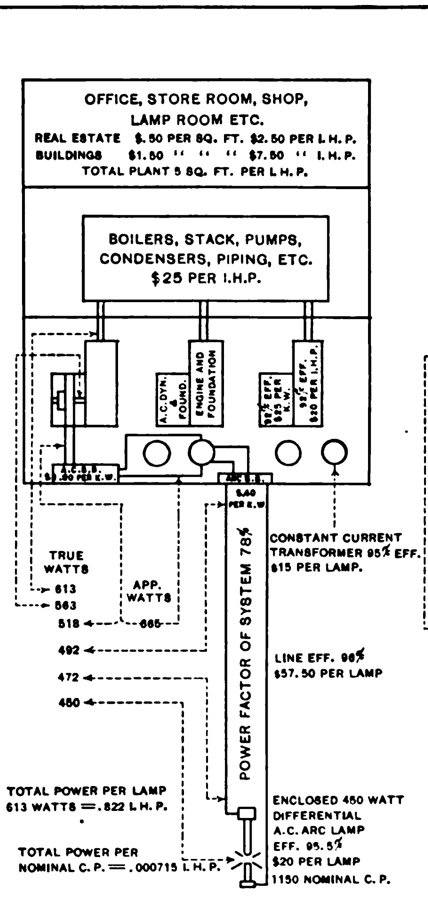
TOTAL COST PER LAMP.

Real estate	$1.90
Buildings	5.60
Boilers, etc	18.60
Engines	14.90
Alternating current generators	15.00
Alternating current switchboard	.60
Constant current transformers	15.00
Arc switchboard	.20
Line	54.70
Lamp	20.00
	$146.50

Total per Nominal Candle Power, $0.154.

COST PER LAMP PER YEAR OF 3,800 HOURS.

Coal and water	$11.85
Wages	8.50
Superintendent and office	2.00
Int., taxes ins., 7 per cent. Depreciation, 6 per cent. } 13 per cent.	19.20
Extra depreciation arc lamp. 4 per cent.	80
Repairs, renewals and supplies at $2.50 per i.h.p.	1.86
Extra repairs a. c. trans., $0.20 per i.h.p.	.15
Trimming lamps	5.20
Carbons	1.90
Globes	1.60
Total operating expenses	$52.86
Oper. expenses per Nominal Candle Power	$0.0556



OFFICE, STORE ROOM, SHOP, LAMP ROOM ETC.
REAL ESTATE $.50 PER SQ. FT. $2.50 PER I. H. P.
BUILDINGS $1.50 " " " $7.50 " I. H. P.
TOTAL PLANT 5 SQ. FT. PER I. H. P.
BOILERS, STACK, PUMPS, CONDENSERS, PIPING, ETC. $25 PER I.H.P.
A.C.DYN. & FOUND.
ENGINE AND FOUNDATION
92% EFF. $25 PER K.W.
92% EFF. $20 PER I.H.P.
A.C.S.B. $1.20 PER K.W.
ARC S.B.
$.40 PER K.W.
TRUE WATTS
613
563
APP. WATTS
518
665
492
472
450
POWER FACTOR OF SYSTEM 78%
CONSTANT CURRENT TRANSFORMER 95% EFF. $15 PER LAMP.
LINE EFF. 96% $57.50 PER LAMP
TOTAL POWER PER LAMP 613 WATTS = .822 I. H. P.
TOTAL POWER PER NOMINAL C. P. = .000715 I. H. P.
ENCLOSED 450 WATT DIFFERENTIAL A.C. ARC LAMP EFF. 95.5% $20 PER LAMP 1150 NOMINAL C. P.

FIG. 2.—ALTERNATING CONSTANT CURRENT TRANSFORMER.

450-WATT ENCLOSED ARC.

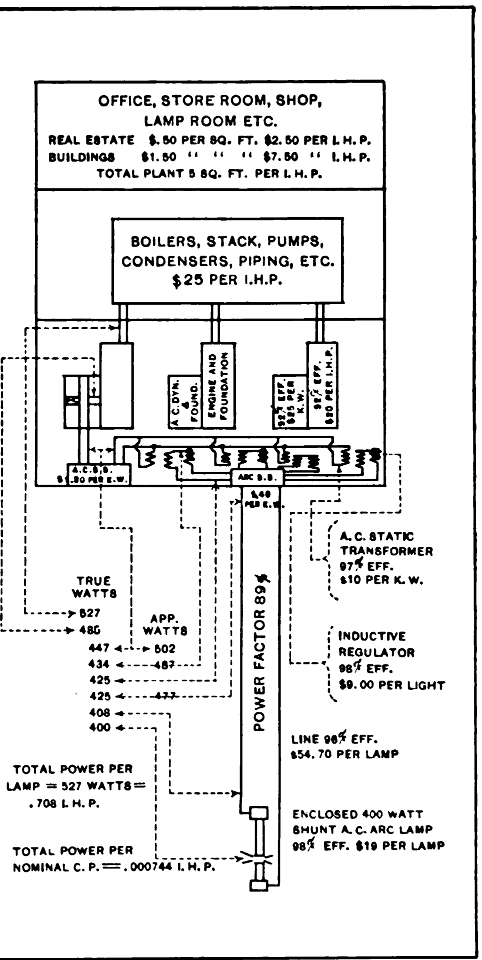
TOTAL COST PER LAMP.

Real estate	$2.05
Buildings	6.16
Boilers, etc	20.50
Engines	16.45
Alternating current generators	16.60
Alternating current switchboard	.78
Constant current transformers	16.00
Arc switchboard	.20
Line	57.50
Lamp	20.00
	$155.24

Total per Nominal Candle Power, $0.1319.

COST PER LAMP PER YEAR OF 3,800 HOURS.

Coal and water	$13.10
Wages	9.35
Supterintendent and office	2.00
Int., taxes, ins., 7 per cent. Depreciation, 6 per cent. } 13 per cent.	20.20
Extra dep. act. arc lamp, 4 per cent	80
Repairs, renewals and supplies at $2.50 per i h p	2.26
Extra repairs a. c. trans., $0.20 per i.h.p.	18
Trimming lamps	5.86
Carbons	2.30
Globes	1.80
Total operating expenses	$57.85
Oper. expenses per Nominal Candle Power	$.0530



OFFICE, STORE ROOM, SHOP, LAMP ROOM ETC.
REAL ESTATE $.50 PER SQ. FT. $2.50 PER I. H. P.
BUILDINGS $1.50 " " " $7.50 " I. H. P.
TOTAL PLANT 5 SQ. FT. PER I. H. P.
BOILERS, STACK, PUMPS, CONDENSERS, PIPING, ETC. $25 PER I.H.P.
A.C.DYN. & FOUND.
ENGINE AND FOUNDATION
92% EFF. $25 PER K.W.
92% EFF. $20 PER I.H.P.
A.C.S.B. $1.20 PER K.W.
ARC S.B.
$.40 PER K.W.
TRUE WATTS
527
485
APP. WATTS
447
502
434
487
425
425
477
408
400
POWER FACTOR 89%
A.C. STATIC TRANSFORMER 97% EFF. $10 PER K.W.
INDUCTIVE REGULATOR 98% EFF. $9.00 PER LIGHT
LINE 98% EFF. $54.70 PER LAMP
TOTAL POWER PER LAMP = 527 WATTS = .708 I. H. P.
TOTAL POWER PER NOMINAL C. P. = .000744 I. H. P.
ENCLOSED 400 WATT SHUNT A.C. ARC LAMP 98% EFF. $19 PER LAMP

FIG. 3.—A. C. SERIES INDUCTIVE REGULATOR SYSTEM.

400-WATT ENCLOSED.

TOTAL COST PER LAMP.

Real estate	$1.80
Buildings	5.30
Boilers, etc	17.70
Engines	14.20
Alternating current generators	12.50
Alternating current switchboard	50
Static transformer	4.90
Regulator	9.00
Arc switchboard	20
Line	54.70
Lamp	19.00
	$139.80

Total per Nominal Candle Power, $0.147.

COST PER LAMP PER YEAR OF 3,800 HOURS.

Coal and water	$11.30
Wages	8.07
Superintendent and office	2.00
Int., taxes, ins., 7 per cent. Depreciation, 6 per cent. } 13 per cent.	18.15
Extra dep. act. arc lamp, 4 per cent	76
Repairs, renewals and supplies at $2.50 per i.h.p	1.77
Trimming lamps	5.20
Carbons	1.90
Globes	1.60
Total operating expenses	$50.75
Oper. expenses per Nominal Candle Power	$0.0535

If the mean hemispherical candle powers had been taken, the ratio would have been more advantageous to the open arc, but the distribution is so much more even with the enclosed arc that the lighting is generally more serviceable and consequently the mean spherical values were thought to give a reasonably fair basis of comparison.

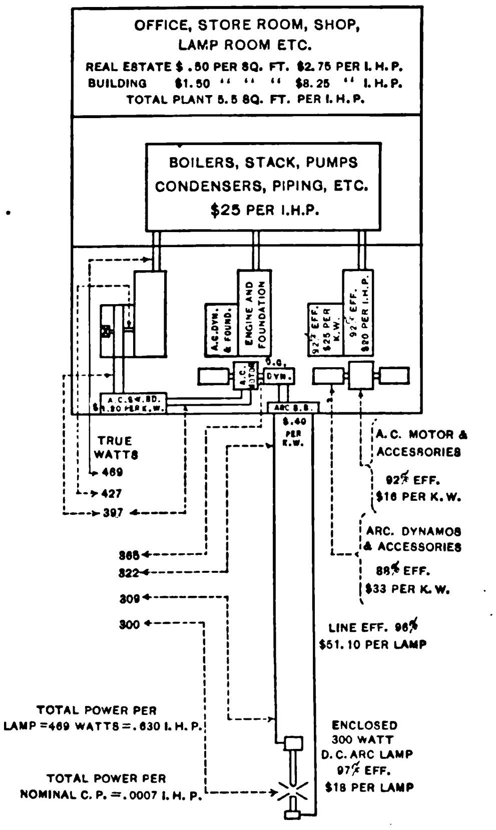
For commercial lighting in stores, the superior distribution and steadiness of an enclosed arc undoubtedly give it so many advantages that for these cases it should be rated on a par with the open arc. For street lighting, however, the volume and intensity of the light are more important than the quality, and as the tables refer more especially to systems serviceable for street lighting, the above ratio was taken.

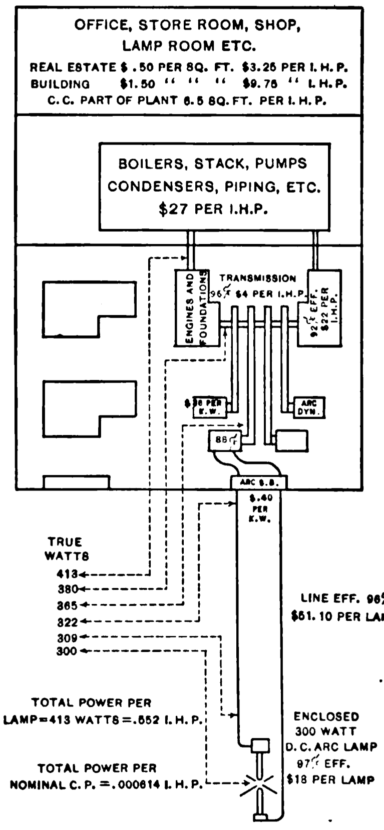
There is very little reliable information at hand for comparing a. c. and d. c. enclosed lamps. What there is seems to show that it requires 33 1-3 per cent. more watts to give the same candle power in a.c. lamps as in d.c. lamps.

From the above ratios it will be seen that if 1200 c. p. is a fair nominal value for a 300-watt open arc, the enclosed d. c. might be called 900. A 300-watt a. c. enclosed would be approximately 675, and a 400-watt increased in the ratio of the watts would give 900. The candle power would undoubtedly increase more than in the ratio of the watts, and 950 has been taken as a mean value in working up from the 1200 c. p. open and down from the 2000 c. p. open d. c.

The resulting costs have been divided by all the nominal candle powers so that the cost can be compared readily at any reasonable rating.

It is only recently that much attention has been paid to the distribution of light at different distances along the street. The alternating-current lamp with its maxi-


OFFICE, STORE ROOM, SHOP,
LAMP ROOM ETC.
REAL ESTATE $ .50 PER SQ. FT. $2.75 PER I. H. P.
BUILDING $1.50 " " " $8.25 " I. H. P.
TOTAL PLANT 5.5 SQ. FT. PER I. H. P.
BOILERS, STACK, PUMPS
CONDENSERS, PIPING, ETC.
$25 PER I.H.P.
A.C.DYN. & FOUND.
ENGINE AND FOUNDATION
92% EFF. $25 PER K.W.
92% EFF. $20 PER I.H.P.
A.C. MOTOR
D.C. DYN.
A.C.SW.BD. $1.20 PER K.W.
ARC S.B. $.40 PER K.W.
TRUE WATTS
469
427
397
365
322
309
300
A.C. MOTOR & ACCESSORIES
92% EFF.
$16 PER K.W.
ARC. DYNAMOS & ACCESSORIES
88% EFF.
$33 PER K.W.
LINE EFF. 96%
$51.10 PER LAMP
TOTAL POWER PER LAMP =469 WATTS =.630 I. H. P.
TOTAL POWER PER NOMINAL C. P. =.0007 I. H. P.
ENCLOSED 300 WATT D.C. ARC LAMP 97% EFF. $18 PER LAMP


OFFICE, STORE ROOM, SHOP,
LAMP ROOM ETC.
REAL ESTATE $ .50 PER SQ. FT. $3.25 PER I. H. P.
BUILDING $1.50 " " " $9.75 " I. H. P.
C.C. PART OF PLANT 6.5 SQ. FT. PER I. H. P.
BOILERS, STACK, PUMPS
CONDENSERS, PIPING, ETC.
$27 PER I.H.P.
ENGINES AND FOUNDATIONS
TRANSMISSION
96% $4 PER I.H.P.
92% EFF. $22 PER I.H.P.
$36 PER K.W.
ARC DYN.
88%
ARC S.B.
$.40 PER K.W.
TRUE WATTS
413
380
365
322
309
300
LINE EFF. 96%
$51.10 PER LAMP
TOTAL POWER PER LAMP=413 WATTS=.552 I. H. P.
TOTAL POWER PER NOMINAL C. P. =.000614 I. H. P.
ENCLOSED 300 WATT D.C. ARC LAMP 97% EFF. $18 PER LAMP

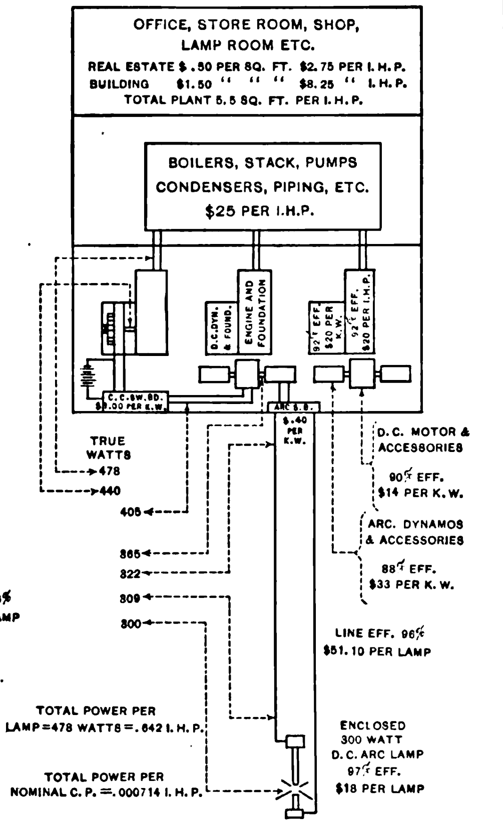

OFFICE, STORE ROOM, SHOP,
LAMP ROOM ETC.
REAL ESTATE $ .50 PER SQ. FT. $2.75 PER I. H. P.
BUILDING $1.50 " " " $8.25 " I. H. P.
TOTAL PLANT 5.5 SQ. FT. PER I. H. P.
BOILERS, STACK, PUMPS
CONDENSERS, PIPING, ETC.
$25 PER I.H.P.
D.C.DYN. & FOUND.
ENGINE AND FOUNDATION
92% EFF. $20 PER K.W.
92% EFF. $20 PER I.H.P.
C.C.SW.BD. $3.00 PER K.W.
ARC S.B. $.40 PER K.W.
TRUE WATTS
478
440
405
365
322
309
300
D.C. MOTOR & ACCESSORIES
90% EFF.
$14 PER K.W.
ARC. DYNAMOS & ACCESSORIES
88% EFF.
$33 PER K.W.
LINE EFF. 96%
$51.10 PER LAMP
TOTAL POWER PER LAMP=478 WATTS=.642 I. H. P.
TOTAL POWER PER NOMINAL C. P. =.000714 I. H. P.
ENCLOSED 300 WATT D.C. ARC LAMP 97% EFF. $18 PER LAMP

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FIG. 4.—D. C. ARC MACHINES DRIVEN BY A. C. MOTORS.

300-WATT ENCLOSED.

TOTAL COST PER LAMP.

Real estate	$1.72
Buildings	5.20
Boilers, etc	15 70
Engines	12 60
Alternating current generators	10.00
Alternating current switchboard	50
Alternating current motors	5 80
Arc dynamos	10 61
Arc switchboard	20
Line	51.10
Lamp	18.00
	$131.42

Total per Nominal Candle Power, $0.146.

COST PER LAMP PER YEAR OF 3,800 HOURS.

Coal and water	$10.05
Wages	8.85
Superintendent and office	2.00
Int., taxes, ins., 7 per cent. Depreciation, 6 per cent... } 13 per cent.	17.10
Extra dep. act. arc dynamo, 4 per cent	42
" " " " lamp, 4 per cent	72
Repairs, renewals and supplies at $2.50 per i.h.p.	1.57
Extra repairs arc dynamo at $50 per i.h p...	32
Trimming lamps	2.60
Carbons	1.40
Globes	1.00
Total operating expenses	$46.03
Oper. expenses per Nominal Candle Power	$0.0512

FIG. 5.—DIRECT CURRENT BELTED ARC.

300-WATT ENCLOSED.

TOTAL COST PER LAMP.

Real estate	$1.80
Buildings	5.40
Boilers, etc	14.90
Engines	12.10
Transmission	2.20
Arc dynamos	12.20
Arc switchboard	20
Line	51.10
Lamp	18.00
	$117.90

Total per Nominal Candle Power, $0.131.

COST PER LAMP PER YEAR OF 3,800 HOURS.

Coal and water	$8.80
Wages	7.78
Superintendent and office	2.00
Int., taxes, ins., 7 per cent. Depreciation, 6 per cent . } 13 per cent.	15.30
Extra dep. act. arc dynamo, 4 per cent	49
Extra dep. act. arc lamp, 4 per cent	72
Repairs, renewals and supplies at $2.50 per i.h.p	1.38
Extra repairs arc dynamo at $0.50 per i.h.p..	28
Trimming lamps	2.60
Carbons	1.40
Globes	1.00
Total operating expenses	$41.75
Oper expenses per Nominal Candle Power	$0.0464

FIG. 6.—DIRECT CURRENT ARC MACHINES DRIVEN BY DIRECT CURRENT MOTORS.

300-WATT ENCLOSED ARCS.

TOTAL COST PER LAMP.

Real estate	$1.75
Building	5.30
Boilers, etc	16.10
Engines	12 80
Alternating current generators	8.10
Continuous current switchboard	40
Continuous current motors	5.10
Arc dynamos	10.60
Arch switchboard	.20
Line	51.10
Lamp	18.00
	$129.45

Total per Nominal Candle Power, $0.144.

COST PER LAMP PER YEAR OF 3,800 HOURS.

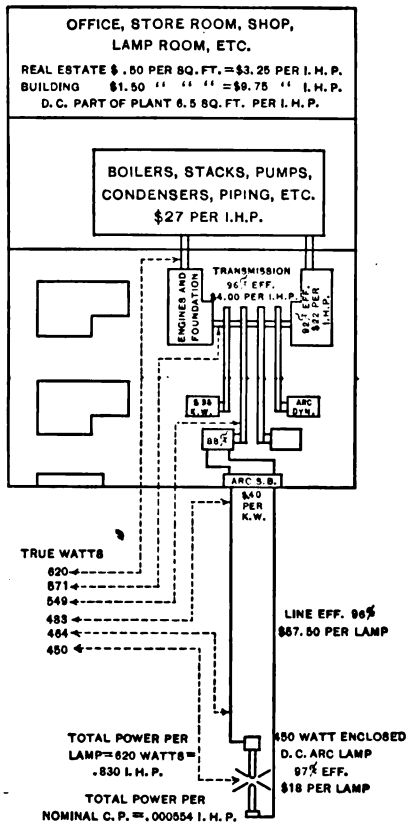
Coal and water	$10.20
Wages	9.00
Superintendent and office	2.00
Int., taxes, ins., 7 per cent. Depreciation, 6 per cent... } 13 per cent.	16.80
Extra dep. act. arc dynamo, 4 per cent	42
Extra dep. act. arc lamp, 4 per cent	72
Repairs, renewals and supplies at $2 50 per i.h.p.	1.60
Extra repairs arc dynamo at $0.50 per i.h.p..	.32
Trimming lamps	2.60
Carbons	1.40
Globes	1.00
Total operating expenses	$46.06
Oper. expenses per Nominal Candle Power,	$0.0513

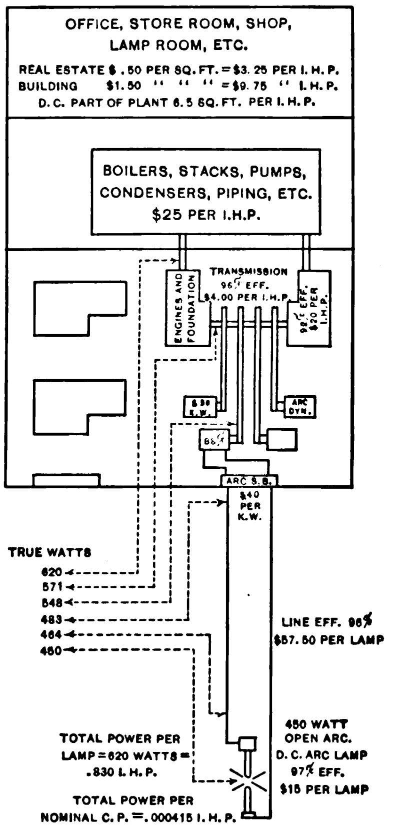
mum illumination near the horizontal plane has advantages in this respect. To get the full benefit of this feature of the lamp it is necessary to suspend the lamp somewhat lower than has been customary with continuous-current lamps. This brings out a feature which is worthy of consideration, namely, the effect of the direct rays on the eyes of the pedestrian or observer. For example, assuming that the illumination of objects from two lamps was equal when the observer was looking in the opposite direction from the lamp; suppose that one of the lamps was placed quite high and the other nearly in his line of vision when looking toward the lamp; it is quite evident that whereas the illuminations of objects is equal, the perceptive power of the pedestrian is decidedly impaired by the glare of the low-hung lamp, and he is not only less able to perceive his surroundings, but would also be considerably annoyed if the lowering of the lamp was carried to extremes.

Another factor in the comparison is that of color, the alternating lamps generally having a larger amount of violet rays. Under certain circumstances this would be an objection, and it should also be noted in this connection that photographic studies of the relative illuminating powers of arc lamps are liable to be very greatly in error on account of the superior actinic value of the violet rays.

The tables are all made out assuming the arc lighting part of the plant to be running at very nearly full load whenever it does run. This will, of course, not apply to commercial lighting circuits and considerable corrections will have to be made for such conditions. The following points might be mentioned in this connection:

The continuous-current arc generators will fall off quite rapidly in efficiency as the load goes down. The engine efficiency will also fall off in the case where the


OFFICE, STORE ROOM, SHOP, LAMP ROOM, ETC.
REAL ESTATE $ .50 PER SQ. FT. = $3.25 PER I. H. P.
BUILDING $1.50 " " " = $9.75 " I. H. P.
D. C. PART OF PLANT 6.5 SQ. FT. PER I. H. P.
BOILERS, STACKS, PUMPS, CONDENSERS, PIPING, ETC. $27 PER I.H.P.
ENGINES AND FOUNDATION
TRANSMISSION 96% EFF. $4.00 PER I.H.P.
92% EFF. $22 PER I.H.P.
$36 K.W.
ARC DYN.
88%
ARC S. B.
$40 PER K.W.
TRUE WATTS
620
571
549
483
464
450
LINE EFF. 96% $57.50 PER LAMP
TOTAL POWER PER LAMP = 620 WATTS = .830 I. H. P.
TOTAL POWER PER NOMINAL C. P. = .000554 I. H. P.
450 WATT ENCLOSED D. C. ARC LAMP 97% EFF. $18 PER LAMP


OFFICE, STORE ROOM, SHOP, LAMP ROOM, ETC.
REAL ESTATE $ .50 PER SQ. FT. = $3.25 PER I. H. P.
BUILDING $1.50 " " " = $9.75 " I. H. P.
D. C. PART OF PLANT 6.5 SQ. FT. PER I. H. P.
BOILERS, STACKS, PUMPS, CONDENSERS, PIPING, ETC. $25 PER I.H.P.
ENGINES AND FOUNDATION
TRANSMISSION 96% EFF. $4.00 PER I.H.P.
92% EFF. $20 PER I.H.P.
$36 K.W.
ARC DYN.
88%
ARC S. B.
$40 PER K.W.
TRUE WATTS
620
571
548
483
464
450
LINE EFF. 96% $57.50 PER LAMP
TOTAL POWER PER LAMP = 620 WATTS = .830 I. H. P.
TOTAL POWER PER NOMINAL C. P. = .000415 I. H. P.
450 WATT OPEN ARC. D. C. ARC LAMP 97% EFF. $15 PER LAMP

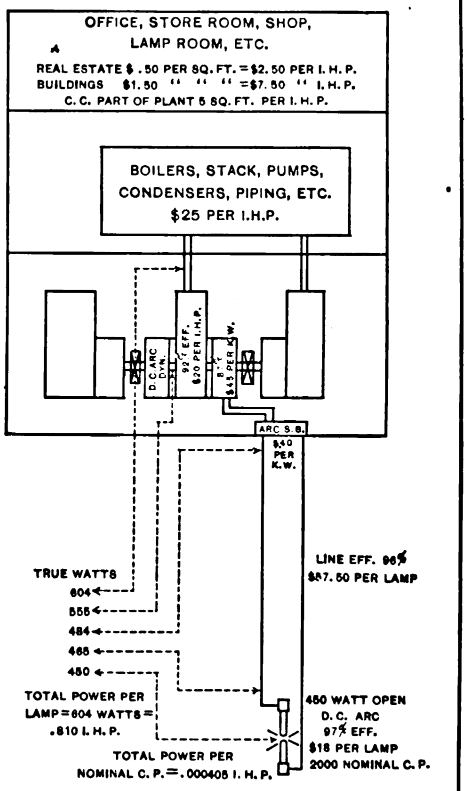

OFFICE, STORE ROOM, SHOP, LAMP ROOM, ETC.
REAL ESTATE $ .50 PER SQ. FT. = $2.50 PER I. H. P.
BUILDINGS $1.50 " " " = $7.50 " I. H. P.
C. C. PART OF PLANT 5 SQ. FT. PER I. H. P.
BOILERS, STACK, PUMPS, CONDENSERS, PIPING, ETC. $25 PER I.H.P.
D.C. ARC DYN.
92% EFF. $20 PER I.H.P.
87% $45 PER K.W.
ARC S. B.
$40 PER K.W.
TRUE WATTS
604
555
484
465
450
LINE EFF. 96% $57.50 PER LAMP
TOTAL POWER PER LAMP = 604 WATTS = .810 I. H. P.
TOTAL POWER PER NOMINAL C. P. = .000405 I. H. P.
450 WATT OPEN D. C. ARC 97% EFF. $18 PER LAMP 2000 NOMINAL C. P.

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FIG. 7.—DIRECT CURRENT BELTED ARC.

450-WATT ENCLOSED.

TOTAL COST PER LAMP.

Real estate	$2.70
Buildings	8.10
Boilers, etc	22.40
Engines	18.25
Transmission	3.32
Arc dynamo	16 90
Arc switchboard	20
Line	57.50
Lamp	18.00
	$147.37

Total per Nominal Candle Power, $0.0982.

COST PER LAMP PER YEAR OF 3.800 HOURS.

Coal and water	$13 25
Wages	11.68
Superintendent and office	2.00
Int., taxes, ins., 7 per cent. Depreciation, 6 per cent... } 13 per cent	19.10
Extra dep. act arc dynamo, 4 per cent	68
Extra dep. act. arc lamp, 4 per cent	72
Repairs, renewals and supplies at $2.50 per i.h.p	2.07
Extra repairs arc dynamo at $0.50 per i.h.p.	42
Trimming lamps	3.15
Carbons	1.70
Globes	1 30
Total operating expenses	$56.07
Oper. expenses per Nominal Candle Power	$0.0374

FIG. 8.—DIRECT CURRENT BELTED OPEN ARC.

450-WATT.

TOTAL COST PER LAMP.

Real estate	$2.70
Buildings	8.10
Boilers, etc	20.80
Engines	16.65
Transmission	3.30
Arc dynamos	18.35
Arc switchboard	20
Line	57 50
Lamp	15.00
	$142.60

Total per Nominal Candle Power, $0.0713.

COST PER LAMP PER YEAR OF 3,800 HOURS.

Coal and water	$13 30
Wages	11.70
Superintendent and office	2 00
Int., taxes, Ins, 7 per cent. Depreciation, 6 per cent. } 13 per cent	18.50
Extra dep. act. arc dynamo, 4 per cent	73
Extra dep. act. arc lamp, 4 per cent	60
Repairs, renewals and supplies at $2.50 per i.h.p.	2.08
Extra repairs arc dynamo at $0.50 per i.h.p.	.42
Trimming lamps (daily)	11.60
Carbons	7.50
Globes	.70
Total operating expenses	68.53
Oper. expenses per Nominal Candle Power,	$0.0342

FIG. 9.—DIRECT CURRENT DIRECT DRIVEN ARC.

450-WATT OPEN.

TOTAL COST PER LAMP.

Real estate	$2.00
Buildings	6.10
Boilers, etc	20.20
Engines	16.20
Arc dynamo	21.80
Arc switchboard	20
Line	57.50
Lamp	18.00
	$142.00

Total per Nominal Candle Power, $0.071.

COST PER LAMP PER YEAR OF 3,800 HOURS.

Coal and water	$12.90
Wages	11.40
Superintendent and office	2.00
Int., taxes, ins., 7 per cent. Depreciation, 6 per cent } 13 per cent	18.50
Extra dep. act. arc dynamo, 4 per cent	83
Extra dep. act. arc lamp, 4 per cent	72
Repairs, renewals and supplies at $2.50 per i.h.p	2.02
Extra repairs arc dynamo at $0.50 per i h.p.	41
Trimming lamps (alternate days)	6.50
Carbons	6.80
Globes	50
Total operating expenses	$62.58
Oper. expenses per Nominal Candle Power.	$0.0313

machines are operated directly from the engines until the load is sufficiently reduced to permit shutting down one of the engine units. Some a. c. systems have the disadvantage that it is not practicable to operate them at all on very light loads, but the efficiency is not very greatly reduced at light load, although the decrease in efficiency of the system is augmented by the fact that the power factor runs to quite low values at the light loads.

Another point in favor of the alternating systems is the fact that the location of the plant or other local condition may permit a saving in the line investment; for example, where a large number of circuits had to be run for a long distance in the same street, a saving in the investment could probably be made by the alternating systems by the use of a sub-station at the point of distribution. The extra attendance and cost of the sub-station would in most cases partially offset the advantage. Where the extra load would not interfere, the mains already in use might also be used for an alternating system.

In cases where there is already a greater generator capacity installed than is actually needed, it is, of course, possible to leave out a considerable portion of the investment shown in the tables. This would apply to any of the motor-driven continuous-current systems as well as the a. c. systems. See tables 10 and 11.

In rare cases the peak of the commercial lighting and power load would not overlap the arc-lighting load, and under such circumstances some one of the transformer systems, either direct or alternating current, would have a great advantage.

EXPLANATION OF TABLES.

The plants shown in the tables are, of course, intended only as diagrammatic representations of the conditions and not as actual arrangements best suited for the purpose.

The tables are on what might be considered a minimum basis, that is, there is no allowance made for reserve in buildings or real estate, nor is there any allowance for reserve in the generating plant beyond the fact that the engine and dynamo units have been so subdivided as to avoid a great percentage of shut down in case of accident. The cost of line has been reduced, and in fact all other items in the different plans have been reduced to what might be considered a minimum for a first class plant. The alternating plants shown have a slight advantage in the freedom from shut down over the engine-driven, direct-current plants, although in the latter the engine unit is subdivided and an extra allowance is made for this and for arranging one engine to carry the greater part of the load in the case of accident to the other unit. In the case of plan 9, where the Arnold system is suggested, the direct-current plant is not open to this objection, and for that matter any of the direct-current plants could be arranged in this way without very great increase in cost.

VALUES OF ITEMS IN TABLES.

Real estate has been taken at fifty cents per square foot as representing a fair average value, the actual values ranging anywhere from nothing to seven or eight dollars a square foot. Buildings have been taken at one dollar and a half per square foot, the range in this respect being nearly as great as for real estate.

Boilers, foundations, stacks, pumps, condensers, piping and other accessories, have been lumped together at twenty-five dollars per indicated horse power. We have figures on plants where this item runs as low as nine dollars, and as high as forty dollars per indicated horse power of engine. This item has been increased to twenty-seven dollars per i. h. p. in the engine-driven d. c. arc plants to allow for extra accessories on account of subdividing the units. The engine and boiler items are, of course, inter-dependent, as, when the engines are cheap, the tendency is for an increased cost in the boiler plant. The attempt has been made to get an average current market value for all classes of boilers and engines.

Engines and foundations have been figured at twenty dollars per i. h. p. This figure will run as low as ten dollars per i. h. p. and as high as fifty dollars per i. h. p. for high-class triple-expansion verticals. The rate has been increased to twenty-two dollars per i. h. p. on some of the engine-driven arc plants to allow for greater subdivision, etc.

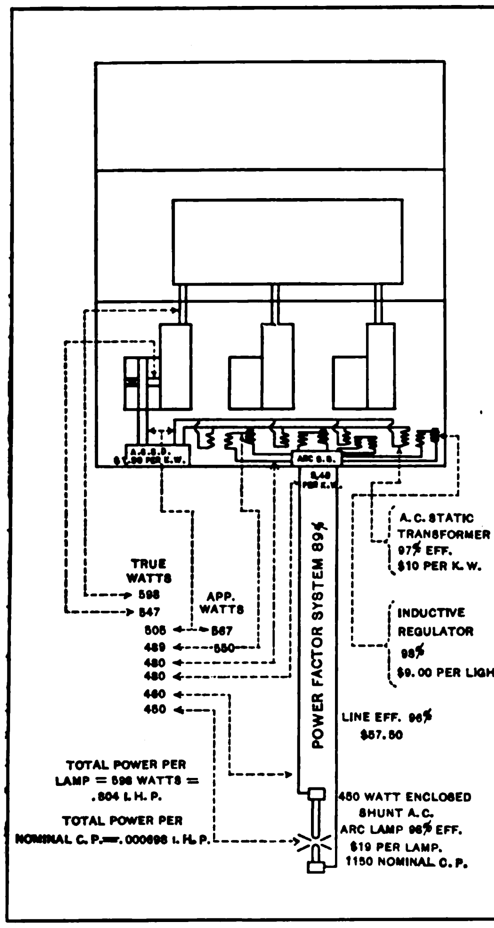
A.C.S.B.
$1.20 PER K.W.
ARC S.B.
$.40 PER K.W.
POWER FACTOR SYSTEM 89%
A. C. STATIC TRANSFORMER
97% EFF.
$10 PER K. W.
INDUCTIVE REGULATOR
98%
$9.00 PER LIGHT
TRUE WATTS
598
547
APP. WATTS
505
567
489
550
480
480
460
450
LINE EFF. 96%
$57.50
TOTAL POWER PER LAMP = 598 WATTS = .804 I. H. P.
TOTAL POWER PER NOMINAL C. P. = .000698 I. H. P.
450 WATT ENCLOSED SHUNT A.C. ARC LAMP 96% EFF.
$19 PER LAMP.
1150 NOMINAL C. P.

FIG. 10.—NO INCREASE IN GENERATING PLANT. ALTERNATING CURRENT SERIES INDUCTIVE REGULATOR SYSTEM.

450-WATT ENCLOSED.

TOTAL COST PER LAMP.

Static transformers	$5.40
Regulator	9.00
Arc switchboard	24
Line	57.50
Lamp	19.00
	$91.14

Total Nominal Candle Power, $0.0795.

COST PER LAMP PER YEAR OF 3,800 HOURS.

Coal and water	$12.81
Wages	9.15
Superintendent and office	2.00
Int., taxes, ins., 7 per cent. Depreciation, 6 per cent. } 13 per cent.	11.90
Extra dep. act. arc lamp, 4 per cent	76
Repairs, renewals and supplies at $2.50 per i h p.	2.03
Trimming lamps	3.15
Carbons	2.30
Globes	1.80
Total operating expenses	$45.89
Oper. expenses per Nominal Candle Power.	$0.0399

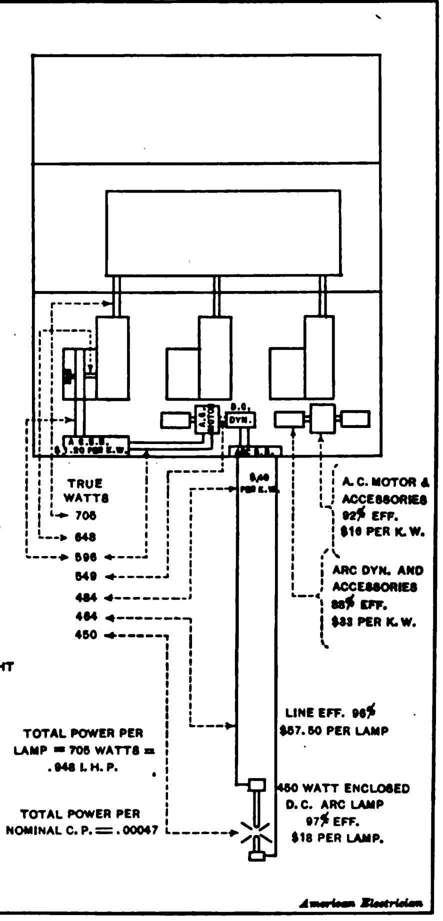
A.C.S.B.
$1.20 PER K.W.
A.C. MOTOR
D.C. DYN.
ARC S.B.
$.40 PER K.W.
TRUE WATTS
705
648
596
549
484
464
450
A. C. MOTOR & ACCESSORIES
92% EFF.
$16 PER K. W.
ARC DYN. AND ACCESSORIES
88% EFF.
$33 PER K. W.
LINE EFF. 96%
$57.50 PER LAMP
TOTAL POWER PER LAMP = 705 WATTS = .946 I. H. P.
TOTAL POWER PER NOMINAL C. P. = .00047
450 WATT ENCLOSED D.C. ARC LAMP
97% EFF.
$18 PER LAMP.
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FIG. 11.—NO INCREASE IN SERIES PLANT. DIRECT CURRENT MACHINES DRIVEN BY ALTERNATING CURRENT MOTORS.

450-WATT ENCLOSED.

TOTAL COST PER LAMP.

Alternating current motors	$8.90
Arc dynamos	15.90
Arc switchboard	20
Line	57.50
Lamp	18.00
	$100.40

Total per Nominal Candle Power, $0.0668.

COST PER LAMP PER YEAR OF 3,800 HOURS.

Coal and water	$15.10
Wages	13.30
Superintendent and office	2.00
Int., taxes, ins., 7 per cent. Depreciation, 6 per cent } 13 per cent.	13.20
Extra dep. act. arc dynamo, 4 per cent	63
Extra dep. act. arc lamp. 4 per cent	72
Repairs, renewals and supplies at $2.50 per i h.p	2.36
Extra repairs arc dynamo at $0.50 per i.h.p.	47
Trimming lamps	3.15
Carbons	1.70
Globes	1.30
Total operating expenses	$53.93
Oper. expenses per Nominal Candle Power	$0.0358

Alternating-current generators and foundations have been taken at $25 per kilowatt as a fair value of what would be put in a modern plant. These figures vary from $12 to $33 per kilowatt. Direct-current arc generators vary in price from less than $30 to $45 per kilowatt. The belted arc machines have been taken at $35 per kilowatt, and the higher speed motor-driven machines at $33 per kilowatt. Large direct-driven machines would average about $45.

Alternating-current constant-current transformers have been taken at $15 per lamp for both 400 and 450-watt lamps, as there is considerable variation in the accessories to these transformers. Alternating-current inductive regulators have been taken at $9 per lamp. This can be made a very variable item on account of the amount of regulation to be provided for as well as other reasons. The figure is intended to cover a regulator to control the entire circuit.

The line has been figured at $51.10 per lamp for the 300-watt enclosed direct-current lamp. This figure was based on the use of hard drawn copper wire with weather-proof covering and the ordinary pole and suspension construction such as would be used in small towns or the outlying districts of cities. The sizes of wire for the other systems has been increased as nearly as possible in the ratio of the current, the other conditions remaining the same. It will be noted that an increase in the cost of this line construction will add a fixed amount to the investment and operating expenses and will not affect the absolute differences between the systems. The percentage differences will vary, however.

The line and pole work such as is used in large cities will run from $100.00 to $150.00 per lamp, while underground cables and conduits will run from $200.00 to $300.00 per lamp.

The other smaller items will be found on the plans.

OPERATING EXPENSES.

Coal and water have been figured at .42 of a cent per i.h.p. hour. The values vary from .28 of a cent per i.h.p. hour to .66; .42 of a cent per i.h.p. hour corresponds with .7 of a cent per kw. hour, with 80 per cent. combined efficiency for engine and dynamo.

Wages have been figured at .15 of a cent per i.h.p. hour in the boiler room; the same in an alternating current dynamo and engine room, and at .22 of a cent in the arc dynamo room. The superintendence and office expenses have been figured at $2.00 per year per lamp in all cases, as this will not vary materially with the kind of plant used.

Interest, taxes and insurance are figured at 7 per cent; depreciation at 6 per cent; this depreciation factor might more strictly be called replacement, as it is intended to include not only real depreciation but also a factor for replacing machinery caused by competition with improvements. A sum at compound interest at 6 per cent would equal the original in eleven and one-half years, so that this would seem to be large enough.

Extra depreciation on arc dynamos and arc lamps has been placed at 4 per cent. This makes a total of 10 per cent for the replacement factor on these portions of the plant. This would cover complete replacement in a little over seven years.

The general repairs, renewals and supplies have been taken at .07 of a cent per i.h.p. hour. Extra repairs on arc dynamos have been taken at .015 per i.h.p. hour. It might be remarked that in several modern arc plants, of which the figures are at hand, this value is considerably less. Extra repairs on alternating-current constant-current transformers have been placed at .007.

The figures for trimming arc lamps have been taken from the data of plants at hand. In all cases we have figures a little more or less than half the values used. In some cases the cost for trimming runs up nearly double the values taken. For example, we have figures varying from $1.00 to $6.25 per lamp per year for direct current enclosed lamps of 400 to 450 watts. The difference comes mainly in the time spent in cleaning the inner globes and in the price of labor as well as the number of lamps taken care of by a man. The figures on enclosed lamps are such as would allow the globes to be kept fairly clean and the cost of trimming alternating enclosed lamps has been increased by a small factor on account of the practice which obtains in some stations of cleaning the globes of these lamps oftener than the direct-current lamps under the same conditions.

The alternating lamps consume their carbons faster than direct-current lamps partly on account of the increased wattage and partly on account of the almost universal practice of using one cored carbon. The use of the cored carbon also materially increases the blackening of the globe. In Plan 10 the 450-watt alternating lamp is assumed to have solid carbons and has the same cost for trimming as the direct-current 450-watt lamp. The cost for globes was taken in the same way as the trimming cost.

	COST PER LAMP PER YEAR OF 3,800 HOURS.	Hartford 400-Watt. Enclosed	Hartford 450-Watt. Enclosed.	Alt. C. Ind. Reg. 400-Watt. Enclosed.	D. C. Arc Driven by A. C. Motors 300-Watt. Enclosed.	D. C. Arc Belted 300 Watt. Enclosed.	D. C. Arc Driven by D. C. Motors 300-Watt. Enclosed.	D. C. Arc Belted 450-Watt. Enclosed.	D. C. Arc Belted 450-Watt. Open Arc.	D. C. Arc Direct Connected 450 Watt. Open D.C.	A. C. Ind. Reg. 450-Watt. Enclosed.	D. C. Arc Driven by A. C. Motors 450-Watt. Enclosed.
		1	2	3	4	5	6	7	8	9	10	11
	Total cost per lamp	$146.50	$155.24	$139.80	$131.42	$117.90	$129.45	$147.37	$142 80	$142.00	$91.14	$100.40
	" " " nominal candle power	.154	.1349	147	.146	131	.144	.0982	.0713	.071	.0795	.0669
	I. H. P. per lamp	.744	.822	.708	.630	.552	.642	.830	.832	.810	.804	.948
	I. H. P. per nominal candle power	.000785	.000715	.000744	.00 700	.000614	.000714	.000554	.0 0415	.000405	.000698	.000631
	OPERATING EXPENSES:											
1	Coal and water	$11.85	$13.10	$11.30	$10 05	$8 80	$10.20	$13.25	$13 30	$12 90	$12.80	$15.10
2	Wages	8.50	9.35	8.07	8 85	7.78	9 00	11.68	11 70	11.40	9.15	13.30
3	Superintendent, office, etc	2.00	2.00	2.00	2.00	2.00	2 00	2 00	2.00	2.00	2.00	2.00
4	Interest, taxes, insurance, 7 per ct Depreciation, 6 per cent. } 13 per ct.	19.00	20.20	18.15	17.10	15.30	16.80	19.10	18.50	18.50	11.90	13 20
5	Extra depreciation arc dynamo	....	....	....	.42	.49	.42	.68	.73	.83	....	.63
6	" " arc lamps	.80	.80	.76	.72	.72	.72	.72	.60	.72	.76	73
7	Repairs, renewals, supplies	1.86	2.26	1.77	1.57	1.38	1.60	2.07	2.08	2.02	2 03	2.38
8	Extra repairs arc dynamo	....	....	....	.32	28	32	.42	.42	.41	....	.47
9	" " constant current transformers	.15	.18	....	....	.....	....	....	....		....	....
10	Trimming	5.20	5.86	5.20	2.60	2.60	2.60	3.15	Daily. 11 00	Alt. days 6.50	3.15	3 15
11	Carbons	1.90	2 30	1.90	1.40	1.40	1.40	1.70	7.50	6 80	2 30	1.70
12	Globes	1.60	1 80	1 60	1 00	1.00	1.00	1.30	.700	.50	1.80	1.30
	Total operating expenses	$52 86	$57.85	$50.75	$46 03	$41.75	$46.06	$56.07	$68.53	$62.58	$45 89	$53 93
	Operating expenses, per 2,000 C. P	.0264	.0289	.0289	.0235	.02087	.0231	.0280	**.0342**	**.0313**	.0230	.0269
	" " rated at 1,500 C. P	.0353	.0385	.0338	.0306	.0278	.0307	**.0375**	.0457	.0417	.0306	**.0359**
	" " " " 1,200 "	.0441	.0482	.0423	.0375	.0348	.0366	.0467	.0572	.0521	.0382	.0448
	" " " " 1,150 "	.0460	**.0503**	.0442	.0402	.0363	.0401	.0490	.0595	.0544	**.0399**	.0468
	" " " " 950 "	**.05570**	.0308	**.0535**	.0484	.0440	.0484	.0591	.0720	.0656	.0484	.0568
	" " " " 900 "	.05880	.0644	.0563	**.0512**	**.0464**	**.0513**	.0624	.0760	.0695	.0559	.0599

Among our Foreign Contemporaries

Majert Accumulator.—In the Elektrotechnische Zeitschrift we find a description of this accumulator, which is manufactured by a German company and appears to have already proved to be quite satisfactory in practice. Some features in its construction make it worth noting.

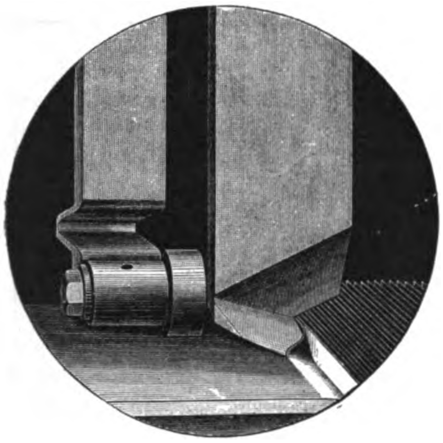


FIG. 1.—THE METHOD OF CUTTING THE GROOVES IN THE POSITIVE PLATES OF THE MAJERT ACCUMULATOR.

The negative plate, which is of the Faure type, consists of frames divided up by a lattice work of peculiar construction, different patterns being used for central stations and for traction work. But the chief interest lies in the construction of the positive plate, which is of the Planté type. To obtain a relatively large surface, the plate is furrowed with very thin and very deep grooves like those of the Willard battery in this country. For a discharge in one to three hours, the depth of a groove is 0.2 inch, the breadth 0.024 inch, and the breadth of a ridge 0.016 inch, so that there are 25 ridges per inch; the thickness of the core plate is 0.04 inch, hence that of the whole plate 0.44 inch; but the weight per square inch of surface is only 1.76 ounces. These plates are made by means of a peculiarly shaped cutting tool on a shaping machine, which is illustrated in the adjoining figure; a slanting shaving is cut off from the surface and is bent up perpendicularly, leaving one edge of it rooted to the plate; the surface of the plate is therefore something like the lower side of a mushroom. The accumulator is in use on some lines of the Berlin tramways, 290 cars being supplied with 58,000 cells. During one year of regular work only 1 per cent of the plates had to be replaced. A cell of the smallest type weighs 21 pounds, and gives 15 or 21 ampere-hours when discharged in ¼ or 1 hour, respectively. A cell of the largest type weighs 119 pounds, and gives 87 or 120 ampere-hours, when discharged in ¼ or 1 hour, respectively.

Electric Tramway Omnibus.—The development of the electric tramway has had to meet more difficulties in Europe than in this country. The trolley system, to which we are so accustomed, has found many opponents abroad, on account of the alleged unsightliness of the overhead wires, and this has led to the use of other much more expensive systems in some places, for æsthetic reasons only. Moreover, there are portions of large cities which were built up long ago, with narrow streets and a crowded population, where it would be exceedingly dangerous and even impossible to lay rails at all, or where for some reasons it is not desirable to lay rails, like on Fifth Avenue, in New York. The traffic, however, wants to cross such districts, and it is for just such purposes that the automobile omnibus of Siemens & Halske, Berlin, illustrated in the adjoining figure, taken from "London Electrician," has been devised. It is specially adapted for connecting street railways through such districts. At the beginning and at the end of its regular trip, it runs as a tramway car on the usual rails and is supplied with current from the overhead wires, both for running and charging an accumulator battery; while in the intermediate part, where there are no rails, it runs as an automobile on the pavement of the streets. The collecting bar which takes the place of the trolley in all the Siemens & Halske systems, is seen lying on the top of the omnibus. The wheels, of course, exactly fit the gauge of the tram line, and the guide wheels shown raised in front, are lowered to make a truck to run on the rails. The omnibus, which in its general appearance follows the lines of the ordinary German type of horse omnibus, has a capacity of fifteen passengers, and there is standing room for six on the rear platform. Steering is accomplished by turning the whole of the front frame, and to diminish the amount of power required from the driver for that purpose, balls are placed between the crown of the moving framework and the corresponding fixed surface on the car body, so that the friction is a rolling instead of a sliding one; this makes so much difference, that while the omnibus is running, it can be steered by means of a handwheel of only 12 inches diameter without intermediate gearing and with one hand, although the front axle has to support a weight of about 3½ tons. For future vehicles, however, it is recommended to gear down between handwheel and turning framework so that the driver may move it while the omnibus is standing still. The four motors, each of 4 h.p. at 300 volts and 550 revolutions, one for each wheel, are connected in parallel. Simple single-reduction gearing is used, 1 : 7.5 for the front wheels and 1 : 8 for the back wheels. As the rails are used for the return current and the spokes of the wheels are wooden, a special conductor between the nave and felloe was necessary. The battery consists of 200 cells, partly placed on the front platform under the driver's seat and partly under the passengers' seats inside, and has a capacity sufficient to drive the car 3.7 miles as an automobile. The battery weighs 1½ tons and the whole omnibus, without passengers, 6½ tons.

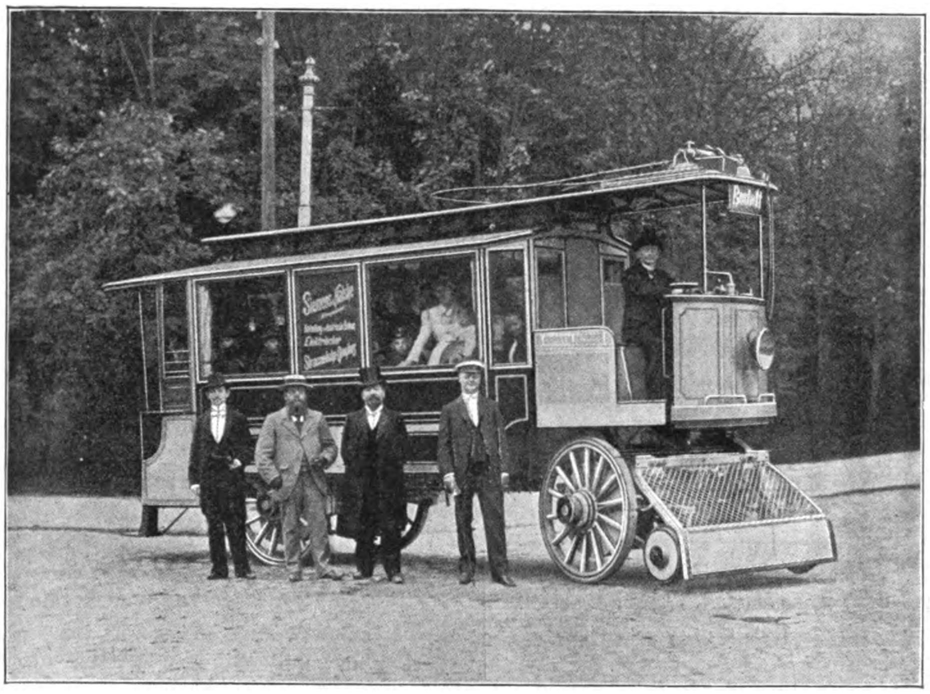


FIG. 2.—A COMBINED TROLLEY CAR AND STORAGE BATTERY AUTOMOBILE.

Lead-Zinc Accumulators.—The fact that when the negative or spongy lead plate of the usual lead accumulator is replaced by zinc, the electro-motive force obtained is considerably higher, being about 2.5 volts, has long been known, and accumulators of this kind have frequently been made, but as far as we can learn they have as frequently been abandoned. The difficulties seem to lie in preventing the zinc from being dissolved by local action, when the cell is not in use, and in the proper deposition of the dissolved zinc on re-charging, as it is apt to develop growths which gradually extend from one plate to the other. Nevertheless the high voltage and the lightness of the cell have been very tempting to inventors. A recent report of a form of this cell devised by Leitner, in the "Elektrotechnischer Anzeiger," states that a small, round cell weighing only 3 pounds, will yield about 9 hours of discharge at a constant current of about two amperes, the voltage falling from 2.56 to 2.1 and the average being 2.34. This corresponds to about 18 ampere-hours or 42 watt-hours per cell, which is at the rate of 5.6 ampere-hours or 13 watt-hours per pound of cell complete with acid. While these results are good, especially as it is a small cell, the report unfortunately does not explain whether the usual objections to these cells have been overcome; the figures therefore serve merely to show what capacity can be obtained. Another inventor of a similar cell overcomes the objection due to local action by emptying the retaining cell whenever the battery is not in use, which is done by having a second tank connected to the cell with a flexible pipe, and then raising or lowering it.

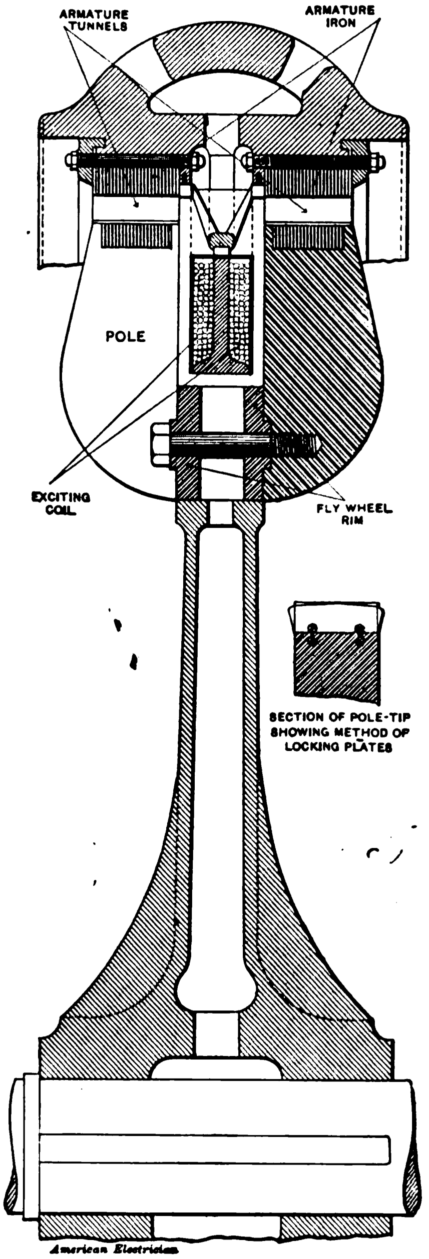

ARMATURE TUNNELS
ARMATURE IRON
POLE
EXCITING COIL
FLY WHEEL RIM
SECTION OF POLE-TIP SHOWING METHOD OF LOCKING PLATES
American Electrician

FIG. 3.—A HALF SECTION THROUGH A GANZ INDUCTOR DYNAMO, SHOWING THE NOVEL ARRANGEMENT OF FLY WHEEL RIM AND POLES.

A Fly-Wheel Inductor-Type Dynamo.—The municipal lighting plant of Leicester, England, has installed a number of inductor-type machines built by Ganz & Company of Budapest, a description of which appears in "The Electrical Engineer," London. The machines differ from inductor-type dynamos built in this country in having their poles independently bolted to the rim of the fly wheel. Fig. 3 shows a section through a half of one of these machines showing the arrangement of the parts. The fly wheel consists of a number of hollow spokes cast in one piece, on which is mounted a cast-steel rim which carries a projecting ring on each side. Bolted tightly to the sides of the rim, and fitting snugly around this ring, are the cast-steel pole pieces. These are staggered, the bolt head for one negative pole coming between two positive poles and vice versa. The 2½-inch bolts do not run through but are tapped into the poles as the figure indicates. The laminated plates of the pole tips are fastened in by molten zinc run into dumbbell shape holes through the laminated plates and cast-steel, as shown in the detail view. This rotating field is excited by a single, concentric, stationary coil wound not in a spool but on a ring with a T section, the turns being held in snugly to the center of the T by band wires. The armature is tunnel wound and with only one tunnel per pole (the machine being single phase). The tunnel is circular and just touches the air gap face of the laminae. The statement is made that after the machine is assembled the winding is threaded by hand through thin tubes of micanite paper driven into these tunnels. This being the case, the winding undoubtedly runs straight through the two armature cores. Apparently the only way of getting at the field coil is to take down half the heavy cast-steel poles.

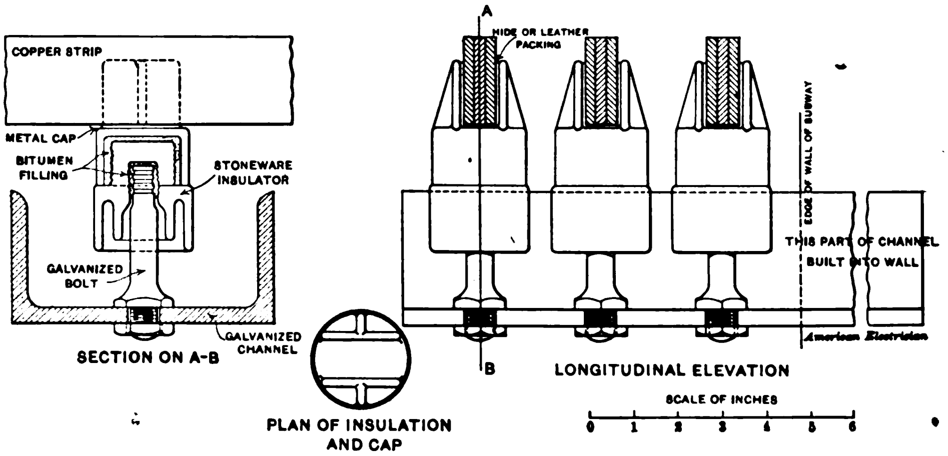

COPPER STRIP
METAL CAP
BITUMEN FILLING
STONEWARE INSULATOR
GALVANIZED BOLT
GALVANIZED CHANNEL
SECTION ON A-B
PLAN OF INSULATION AND CAP
A
HIDE OR LEATHER PACKING
B
EDGE OF WALL OF SUBWAY
THIS PART OF CHANNEL BUILT INTO WALL
LONGITUDINAL ELEVATION
SCALE OF INCHES
0 1 2 3 4 5 6
American Electrician

FIG. 5.—DETAILS OF THE SUPPORTS OF THE FEEDERS IN THE TUNNEL IN EDINBURGH.

Main Feeders in Edinburgh.—In a recent number of the "London Electrical Engineer" there is a long illustrated description of a new lighting station in which a three-wire continuous-current system is used with lamps of 115 volts, while for the outskirts there is a high-tension, alternating-current system at 2500 volts, transformed down to 115 by local transformers. It is the intention, to work this and the older station in parallel, and to shut one down during the hours of light loads. The trunk feeders from the new station are bare copper bars run in underground tunnels and are in some respects similar to analogous mains in open slot railway systems used in this country. The details of the method of supporting the insulators are shown in the two adjoining figures, one showing a cross-section, and the other the longitudinal elevation. As feeders, pure copper strips are used, the standard size of strip being 2 inches broad by ¼ inch thick, the number of strips with any particular feeder varying in accordance with the load on that feeder. These feeders are supported on one of the thin edges, by stoneware insulators which are bolted to channel irons placed at intervals of 10 feet along the conduit. As seen in the figures, the

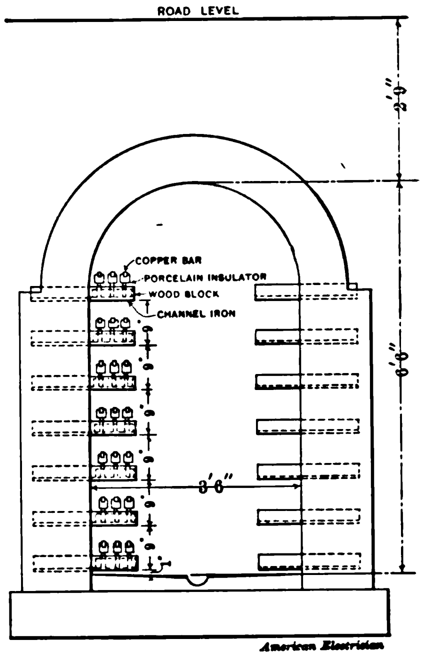

ROAD LEVEL
2'-0"
6'-0"
COPPER BAR
PORCELAIN INSULATOR
WOOD BLOCK
CHANNEL IRON
3'-6"
American Electrician

FIG. 4.—A SECTION THROUGH A WIRE TUNNEL IN EDINBURGH IN WHICH THE FEEDERS ARE COPPER BARS LIKE BUS BARS.

copper is supported in metal caps, which are secured to the stoneware insulators by means of bitumen. Usually these caps provide for three strips each ¼ inch wide, but when a smaller number is used, they can be kept in a vertical position by means of wedges or by an increased thickness of the raw hide or leather packing, shown in the figure. All the iron work used in this conduit is galvanized.

High Voltage Switch.—To open a circuit containing a very high voltage current, it is not always a simple matter, as is well known to those who have tried to do it. Some years ago a German inventor suggested a very ingenious arrangement which we understand has come into use quite extensively for lightning arresters and similar purposes, in which the arc which is formed blows itself out by being forced up through its own repelling action and by the effect of the heat, between two wires like the letter V but not connected at the bottom, so that the arc keeps getting longer and longer and finally breaks. A recent inventor has made use of this principle in devising the switch shown in the adjoining illustration, in which the two bent wires just described are seen. Below these "horns," as they are called, there is an apparatus for closing the circuit. To use this arrangement for breaking the circuit, the current is first switched through this apparatus, as for instance by opening a switch which short circuits the apparatus, the switch below the horns being closed; when the circuit is to be opened this switch is then opened, the arc which passes across immediately jumps to the horns, and rapidly travels upward until it breaks. The switch has been tested on a 600-h.p. alternator when a current of 100 amperes at 5,000 volts was passing, and it is to be installed on 10,000 to 20,000-volt circuits.

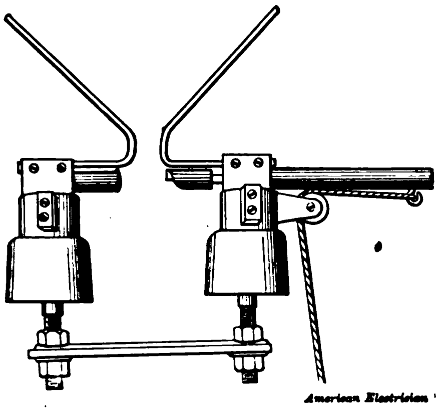
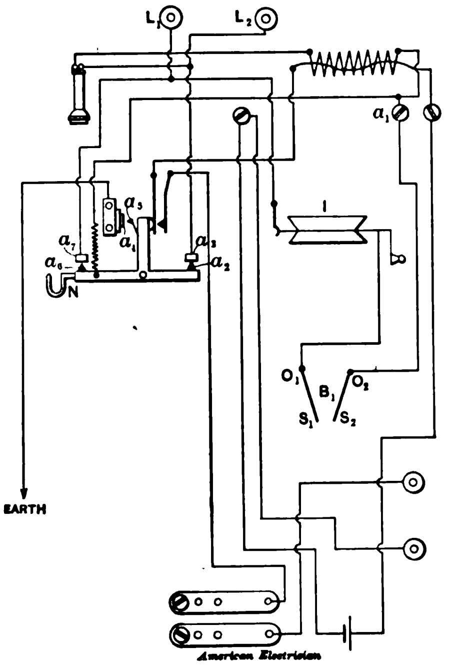

American Electrician

FIG. 6.—A HIGH-TENSION SWITCH WITH AN ARC DISSIPATOR LIKE THE SIEMENS & HALSKE LIGHTNING ARRESTER.

Automatic Telephone.—In the city of Copenhagen, in Denmark, an interesting system of so-called automatic telephone call boxes was introduced about a year ago, and there are at present 465 of these instruments in use, chiefly in public buildings, theaters, and large flats. The tests to which they have been subjected during the past year have shown that the instruments are thoroughly reliable. An illustrated description is published in a recent number of the "London Electrician." The instruments belong to the so-called "penny in the slot" systems; the exchange cannot be called up until a coin, amounting in this case to two and a half cents, has been dropped into the slot, but there is an arrangement so that if the exchange cannot make the desired connection, the coin can be recovered by pressing a button. No ringing off is necessary, as that is accomplished by simply hanging up the receiver on the hook, as in many of the systems used in this country. It is also possible by this means to forward telegrams through the exchange, payment in this case being made by dropping extra coins through the slot.

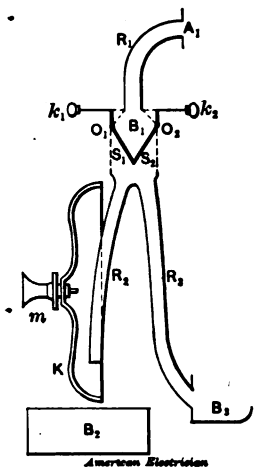


American Electrician

FIG. 7.—THE INSTRUMENT CIRCUITS OF A COIN-IN-THE-SLOT TELEPHONE.

Fig. 8 shows the arrangement for receiving the coin, which is dropped in at A_1 and passes through the flat tube, R_1, into the receptacle, B_1; S_1 and S_2 are two forks, pivoted on O_1 and O_2 and insulated from one another. When a coin rests on B_1, it connects S_1 and S_2, thus completing the circuit through the magnets, I, to the exchange, as will be seen in Fig. 7, and the exchange may now be rung up. If it is possible to make the connection, the caller pushes the button, k_1, and the coin drops through the passage, R_2, strikes the gong, K_1, and falls into B_2; the operator at the exchange hears the coin strike against the gong and then makes the through connection. If, however, connection cannot be made, the button, k_2, is pressed, and the coin is returned through the passage, R_3, into the box, B_3, where the caller can recover it. The connections are shown in Fig. 7. When not in use, the receiver hangs on the hook, N, and a_2 and a_3 make contact. One pole of the magnet, I, is in direct connection with the line, L_1, while the other line, L_2, is broken between S_1 and S_2. After a coin has been dropped in, the circuits through the magnets is completed through O_1,S_1, the coin, $S_2O_2a_1Na_2a_3L^2$ and the exchange can be called. On taking the receiver off the hook, N, the circuit is broken between a_2 and a_3, and contact is made between a_6 and a_7; the connections are then the same as in the usual telephone. When the receiver is replaced on the hook, the line, L_2, is connected through a_4 and a_5 to earth, and the clearing signal is given automatically to the exchange.

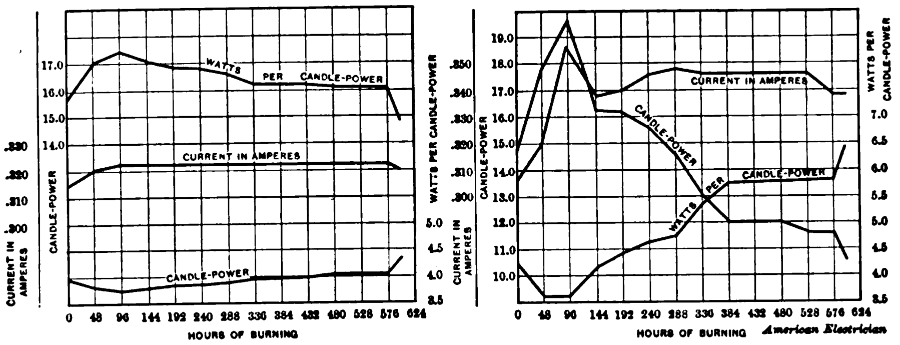
Electro-Deposition of Zinc.—It is well known that there has not yet been found an entirely practical electrolytic zinc process. Even in that of Cowper-Coles for the electrolytic treatment of mixtures of lead sulphide and zinc sulphide carrying silver, described by him in a recent paper before the English Society of Engineers and reprinted in the English electrical journals, not all difficulties seem to have been overcome, although this process has been carefully worked out for many years. The chief difficulty met with in obtaining good deposits of zinc is the formation of zinc sponge, and whoever has worked in this line, knows this to his sorrow. The nature of spongy zinc, and the causes of its formation, have also been the object of a series of laboratory experiments by German electrochemists; a definite result, however, has not yet been arrived at. It seems so far that for obtaining a good zinc deposit, it is best to keep the solution slightly acid. A somewhat peculiar experiment by Cowper-Coles is described in a recent number of the "London Electrician." It was undertaken to ascertain whether the adhesion of electro-deposited zinc to iron and steel could be increased by depositing the zinc under hydraulic pressure, and also whether the physical properties of the deposit might be improved in this way. The solution was contained in a specially constructed cylinder under a pressure of one ton per square inch; he found that for a current density of 50 amperes per square foot, the deposit was beautifully smooth and close-grained, while for other current densities both higher and lower, the deposit was not so



American Electrician

FIG. 8.—THE GONG AND PATH OF THE COIN OF AN AUTOMATIC TOLL TELEPHONE.

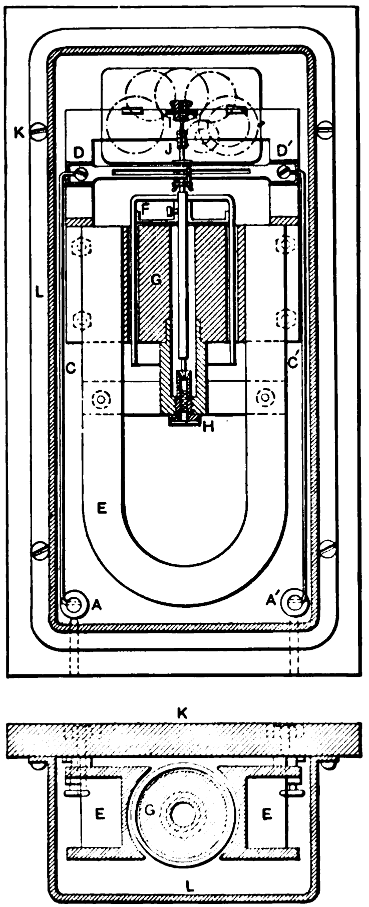
good. Whether these experiments may lead to an industrial process, does not appear so far. Perhaps a better zinc deposit might be obtained by another method, analogous to that used in the Elmore copper process, namely, by burnishing the deposit by mechanical pressure, in order to hinder the formation of small prominences which, when once started, tend in the usual process of electrolysis to grow rapidly.



American Electrician

FIG. 9.—ALLEGED GOOD AND BAD PERFORMANCES OF ENGLISH HIGH-TENSION LAMPS.

Some English High-Voltage Lamps.—In this country the long filaments necessary for high-voltage lamps are almost invariably of the coiled or oval-anchored type, with several coils or ovals to give the necessary length. Abroad, some other shapes of filaments are adopted which appear odd to American eyes. The "London Electrician" recently published illustrations of many types, among which were those reproduced in the accompanying illustration, Fig. 10. These filaments have a sinuous zigzag form which accommodates considerable length in a moderate sized bulb, but which would apparently be subject to the disadvantage of possible entanglement of the separate zigzags and consequent short circuiting. Especially is this true of the lamp shown to the right which is not anchored at any point. In the middle lamp the filament is spread out so that all of its outer curves come near the bulb, dangerously near, it would appear; one loop is anchored to the side of the bulb. The lamp shown to the left has its filament confined to the center of the bulb and anchored at the lowermost point to the tip. A practical disadvantage of these forms in the construction of the lamp is the fact that the turns are so sharp that the filament undoubtedly could not be straightened out to measure its length as can the filament of American types. Also, there is but little room for the adjustment of the length, which adjustment is necessary, as the filament cannot be made to uniform cross section. The short legs at the upper ends of the filaments allow but little room for adjustment; in fact, in the lamp shown to the right there are no legs at all, and any change of length must be taken up in the zigzag portion of the filament itself. The same article mentions the work of a corporation entitled "The Electric Tested Lamp Company," which is practically an expert lamp middleman purchasing lamps which satisfactorily meet average candle power, efficiency and life tests, and selling them to consumers. Fig. 9 gives two sets of curves, one set representing the performance of what is considered a good average 200-volt lamp and the other a poor average 200-volt lamp. The first of these curves, in which the words "candle-power" and "watts per candle-power" have been interchanged, indicates that the lamp tested remained over 16 c.p. for 576 hours. This high maintenance of candle-power is unattainable in this country with high-voltage lamps, which are necessarily untreated, or, what is worse, only treated slightly. It is probably safe to state that this result is also commercially unattainable in England, and this and several similar curves are imaginary. The current curve in the second diagram shows also a peak utterly at variance with usual lamp practice.



American Electrician

FIG. 11.—AN AMPERE HOUR METER HAVING A MOTOR RUNNING WITHOUT A BRAKE.

O'Keenan Meter.—In a recent number of "L'Industrie Electrique" there is a description of the meter devised by O'Keenan, which consists of a small motor without a brake, shunted round a resistance in series with the circuit. The motor is of high efficiency, and runs with a constant magnetic field; as the current taken by it and the friction of the moving parts are very small, the speed of the motor is very nearly proportional to the difference of potential at its terminals, and therefore also to the current in the mains, so that it registers ampere hours. As shown in the illustration, Fig. 11, the meter contains a fixed, soft iron cylinder, surrounded by the pole pieces of a permanent magnet, as in the d'Arsonval type of galvanometer, or as in the Weston instruments. In the cylindrical air gap between the pole pieces and the iron core, a drum winding rotates, which is connected with a commutator and brushes. This ampere-hour meter, as well as a similar watt-hour meter and analogous instruments for alternating currents appear to have been used in practice in France for some time, and to have given satisfactory results.

Resistance and Current Capacity of Carbon Brushes.—The resistance of carbon is necessarily a very indefinite quantity, depending upon the materials and methods of manufacture, but the following data given by Mr. Scott, in a recent article in the "London Electrical Review," in which he proposes to standardize carbon brushes may be of some value as a general guide. For the best quality of brush carbon which has been graphitized by being subjected electrically to a very high temperature, he gives a specific resistance of 1500 microhms per cubic centimeter; this is quite homogeneous and is said to keep the surface of the commutator in a very good condition. The current density which may be used with this carbon is about 97 amperes per square inch of surface contact with the commutator. The next best quality of graphitized carbon has a specific resistance of about 4500 microhms per cubic centimeter, and the current density is about 77 amperes per square inch. A certain brush carbon

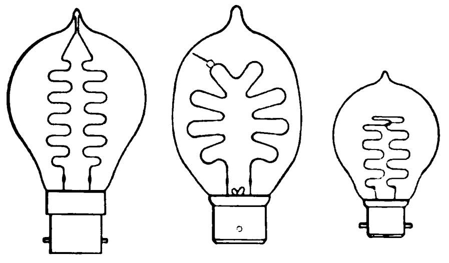


FIG. 10.—ILLUSTRATIONS OF ENGLISH HIGH-VOLTAGE LAMPS SHOWING AN ODD METHOD OF ARRANGING LONG FILAMENTS.

baked in the ordinary way, and one which has been in use for some years, has a specific resistance of about 6000 microhms per cubic centimeter, and the allowable current density is about 52 amperes per square inch. A certain cheaper quality has a specific resistance of 4500 microhms per cubic centimeter, and the current density may be about 45 amperes per square inch; this latter quality of carbon, he says, answers well enough and is quite suitable for heavy currents. He adds that the above-mentioned current densities are the maximum that should be allowed and recommends about two-thirds of these figures for normal work. For the successful use of carbon brushes the connection between the carbon block and the holder must be very good; he suggests that a hole may be drilled in the carbon block and a flexible cable soldered into it; coppering is advisable when the carbons are merely gripped between two surfaces; as the brush holder should be as light as possible, some makers make it of aluminum. For the pressure, he recommends about ¾ pound per square inch for the graphitic carbons, and 1½ pounds for the ordinary carbon. The surface of the commutator should be dead true and preferably burnished.

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THE HOT-WATER HEATING SYSTEM OF THE NEW BOSTON TERMINAL STATION.

The isolated plant of this mammoth structure is described in detail in a paper presented at the recent convention of the American Society of Mechanical Engineers by Mr. W. C. Kerr of Westinghouse, Church, Kerr & Company, the engineers and contractors for the entire mechanical equipment. In this statement there appears an account of the ventilation and heating of the station, from which the following is abstracted:

Hot water was chosen for the circulating medium only after a thorough study of the possibilities and limitations in the use of both steam and hot water. This made it evident that a hot-water circulating system in the form of a loop with return mains in a transverse subway under the tracks not only overcame all physical difficulties encountered in the problem of distribution, but, under the rather unusual conditions which surrounded the heating plant, was superior in every respect. The rapid circulation secured by the use of pumps made all points in the system equally accessible and easy to heat. The amount of water necessary to supply the heat required could be conveyed in a flow main no larger than 8 inches in diameter, and without difficulty due to unavoidable pockets at certain points.

Owing to the storage value of the large body of water contained in the system, the surplus of waste exhaust steam at periods of heavy load could be absorbed within limits for use when there might be a deficiency of exhaust due at times to reduction of load, and be utilized to a greater extent than possible by other methods. Furthermore, while all heating apparatus must be adequate for the severest weather conditions, the hot-water system possessed the considerable advantage of being capable of operating at lowered temperatures corresponding to mild or moderate weather, this preventing waste and discomfort from over-heating and undue radiation losses in the extensive pipe system.

The water is circulated by one of two 8-inch centrifugal pumps, each driven at a speed of about 375 revolutions per minute by an 8½ by 8-inch Standard engine. The water reaches the pump suctions through the 8-inch return main, and is delivered to the supply side of the system after becoming heated to a suitable temperature in a central heating plant located near the circulating pumps in the power house. This consists of three specially designed heaters, two being for exhaust, and a third and smaller one for the use of live steam whenever there may be an insufficient supply of exhaust. Two exhaust heaters were used largely because of the inexpediency of installing a single heater of large dimensions, and partly on account of the advantage of having the principal part of the heating plant in duplicate, and in regulation, by subdivision. The exhaust-steam heaters are capable of condensing 24,000 pounds, and the live-steam heater approximately 18,000 pounds steam per hour, live steam being admitted to the heater only to supply deficiency, the quantity being regulated by an automatic thermostat valve.

The heated water passes from the central heating plant into the flow main and to the exterior circuit which forms a loop, over five-eighths of a mile in length. This entire system, in which there is necessarily a large amount of expansion and contraction, contains no expansion joints, the design of the piping and the free use of long-sweep pipe bends permitting the strains due to expansion to be taken up without imposing undue stress on the fiber or joint. All turns in the flow and return mains were made by these bends, no elbows being used, thus materially reducing the circulating head, which would otherwise have been excessive unless larger and more expensive mains were provided. The engineering problem involved in the proper design, support and anchoring of these hot-water mains was not the least interesting of the several somewhat unusual features of the work. In this connection it is interesting to note that the actual concentrating head proved to be within 2 per cent. of the estimated amount.

Branch connections are made from the mains to five indirect heating chambers, besides many risers and drops connecting with direct radiators, and the entire piping system is thoroughly covered with non-conducting material. The heating chambers are located at various points in the basements of the head house and baggage wings, and contain the necessary primary heating stacks to temper the air supplied to the building for ventilation. In three of the chambers supplementary heaters are provided for further heating the air required for indirect warming. These chambers are air tight and each receives fresh-air supply from above the roofs through vertical intake air shafts. In every case the fresh air is tempered to about 70 degrees and delivered directly or indirectly by means of suitable blower fans through extensive galvanized-iron ducts to the various rooms in the building.

The blower fans are driven by electric motors. They supply to the ventilated portion of the building sufficient air to equal their volume every 15 to 20 minutes. A portion of the tempered air supply is diverted from the fan-discharge ducts and is passed through the supplementary heaters, where this temperature is suitably raised for supplying heat to those portions of the building warmed wholly by the indirect method. The hot air is carried in a separate system of ducts, which parallel the tempered-air ducts, to points where it is delivered to the various rooms. Specially designed mixing dampers are provided for controlling the proportions of hot and tempered air supply. The use of these mixing dampers is such that the total quantity of air supplied is not altered; their office being merely to regulate the relative amounts of hot and tempered air, and thus the temperature of the local mixture. In this way the supply of heat can be increased or diminished without affecting the sufficiency of ventilation.

The form of building, its unusual proportions, and space restrictions, made the matter of air distribution rather a difficult one, and necessitated an extraordinary tightness in the air ducts, especially as the use of the spaces around the supply ducts for exhaust ventilating flues would have made any considerable leakage a matter of consequence. The unavoidable shape of the ducts, their great length, and the opportunity for excessive heat wastes into the discharging air, made it necessary to cover the hot-air supply system with non-conducting material in order to enable the hot air to reach the more distant outlets at full temperature. Asbestos seaweed quilt was used for the work and served its purpose well, although the difficulties in applying any insulating material were considerable. This arrangement was undoubtedly the best that could be employed under the conditions, although simpler means would have been used had they been permissible.

The ventilation of the building is assisted by 11 electrically driven exhaust fans, which are located in corresponding attic fan chambers, and which withdraw the vitiated air from the building through the waste spaces around the air-supply ducts, discharging it above the roofs. The motors by which these fans are driven are of special design, with vertical shafts, and are dust proof.

The fan wheels are mounted on the upper ends of the shafts and the motors are in all cases supported by the roof structure. All portions of the air-circulating system are made fireproof.

Some Recent Electrical Patents.

A Time-Element Circuit Breaker.—The circuits of the Niagara Falls power transmission systems must necessarily pass through a large number of circuit breakers between the generators at the Falls and the power-consuming devices at distant cities, such as Lockport and Buffalo. The step-up transformers at the generating end, the step-down transformers at the receiving end, the feeders branching off and the rotary converters or other transforming devices, if any are used, must each be protected at one or both sides by automatic overload devices. A violent short circuit near the receiving end of a line is likely to open many if not all of these breakers and cut off the power from an extended area instead of simply opening the breaker located nearest to it as it should do. To provide against this, the lines are protected by breakers provided with a time element. That nearest the power-receiving or absorbing device is designed to open instantly when a short-circuit current passes through it. That in the first substation back toward the generator is designed to open only if the short circuit continues, let us say, one second. The next sub-station on the line will only open after a still greater continuance of a short circuit through it, such as three seconds, and that of the generating station may be set for five seconds. Mr. L. B. Stillwell, electrical director of the Niagara Falls Power Company and associated interests, has obtained a patent on this time-element feature. The general arrangement of one instrument is shown in Fig. 1. At the top of the diagram there is represented a series transformer, 3, the primary of which is connected in one leg of the circuit to be protected, the secondary going to the coil, 5, of a solenoid, the armature of which is attached to a detent, engaging the teeth of a ratchet wheel driven by clock-work. This clock-work is fitted with any suitable speed control, such as a fan, and also drives a disc, 14, on which is mounted a conducting strip which in normal position short circuits the latch-releasing mechanism of the circuit breaker proper, which appears in the lower part of the figure in the familiar form of the General Electric breaker. When a short circuit exists on the line the detent, 11, is raised, releasing the disc, 14, which revolves until the coil, 17, of the circuit breaker proper is thrown into circuit, compelling it to operate. By varying the length of the strip on the disc, 14, or the normal position of the clock-work, the time interval between the beginning of a short circuit and the opening of the breaker can be adjusted. Patent No. 633,920.

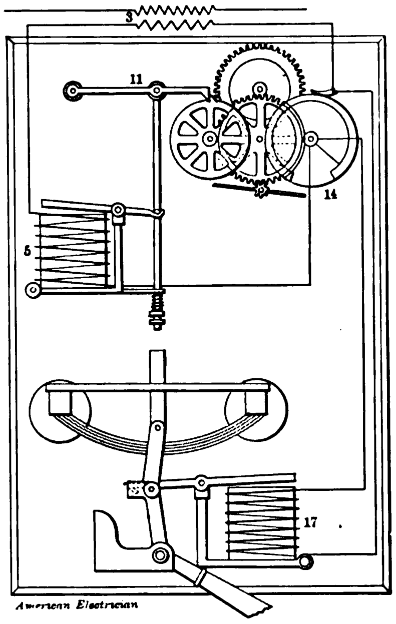

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FIG. 1.—A TIME-ELEMENT CIRCUIT BREAKER.

Enclosed Rheostats.—The resistances used for motor starters are heated for only very brief intervals and with long intermediate periods of rest during which they cool off. On this account they need not have nearly as great a radiating surface as the resistances used in corresponding sizes of motor controllers which may be in service continuously. The heat liberated in the motor starter resistance is largely absorbed in heating up the resistance material itself, but little being given off by radiation and convection of outside air until after the heating stops. If the resistances were surrounded by a material having high specific heat to which they could almost instantly transmit the heat generated within them, their carrying capacity would be greatly increased. This end is attained in a motor starting resistance designed by Mr. H. Ward Leonard which was described on page 486 of the American Electrician of October, 1899. Fig. 2 is reproduced from a patent recently taken out by Mr. Leonard covering the device. The resistance consists of a reflexed ribbon attached to suitable binding posts and enclosed within a box which is filled with a pure grade of fine sand. This material has a high capacity for heat absorption, possesses high insulating properties, and is not readily affected by moisture or heat. The sand being quite fine readily fills all spaces within the box between and around the sections of the resistance and thus effectively insulates the same. The box is made of cast iron and covered on the inside with a layer of porcelain enamel to prevent any moisture from causing a ground. The cover is sealed with putty to prevent the entrance of moisture. Apparatus thus made is strong and compact; the resisting wire is perfectly protected; the cost of manufacture is low; the parts are readily assembled and may be readily taken apart for alteration or repair. The sand is not affected by heat even though the temperature of the conductor reaches the melting point. Mr. Leonard states in the specifications that he has found that a starting box for a 25-h.p. motor assembled as above, need not have dimensions over 14x14x1½ inches, which are much less than those of boxes containing wire coils. Patent No. 635,441.

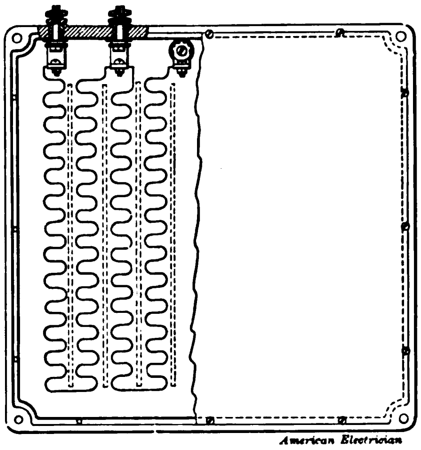
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FIG. 2.—A RHEOSTAT ENCLOSED IN SAND.

A Restoring Device for Measuring Instruments.—Direct current voltmeters and ammeters of the type using a permanent magnet—such, for example, as Weston instruments—usually depend upon spiral springs for a restoring force, these springs serving incidentally to make electrical connections with the pivoted coil. In such instruments any change of the intensity of the permanent magnet or any change of the force of the springs causes a corresponding error in the deflection. Prof. Elihu Thomson has patented an ingenious arrangement for eliminating both these errors by making the restoring force proportional to the intensity of the magnet; thus if the magnet becomes weaker both the deflecting and restoring forces weaken together, introducing no error into the indications. The construction of the instrument is indicated in Fig. 3, where M is a permanent magnet polarizing the usual soft-iron pole pieces. Extending

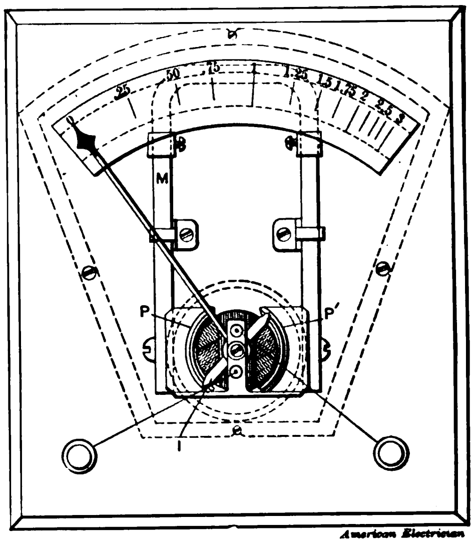

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FIG. 3.—A MAGNETIC RESTORING FORCE FOR INSTRUMENTS.

forward or outward from these pole pieces are the curved iron extensions, P and P′. In front of them and mounted upon the shaft of the removable coil, is the restoring arm, I, which also is of iron. The extensions, P and P′, have sloping faces, the lower corner of P projecting outward more toward the plane of rotation of I than the upper corner and the upper corner of P′ projecting outward more than the lower corner. The restoring arm, I, tends to rotate into the position nearest these projections, since magnetic lines leak from them through the restoring arm. This position is over the corners projecting out the furthest toward the restoring arm, hence the restoring arm tends to set the needle at the zero point of the scale. By suitably curving the faces of the projections a proper restoring force throughout the whole scale can be obtained. Any change of the magnetism changes simultaneously the deflecting force acting upon the coil and the restoring force acting upon the arm and thus causes no change of the deflection. The principle has been embodied in several direct-current instruments made by the General Electric Company. Obviously the magnet could be if desirable made an electromagnet excited by coils connected across the bus bars. Any change of the pressure would not cause an error in the instrument due to the change of magnetization. Patent No. 634,965.

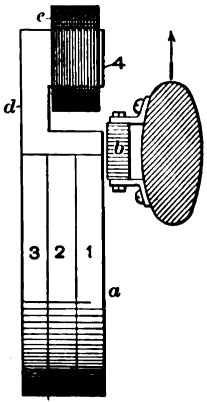

FIG. 4.—A MAGNETIC IGNITER FOR GAS ENGINES.

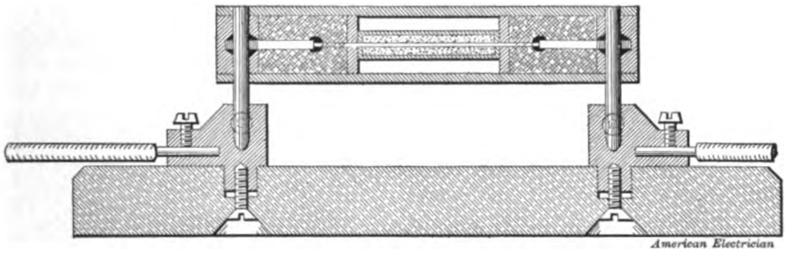

FIG. 5.—AN ENCLOSED FUSE.

An Electric Igniter for Gas Engines.—Electrical ignition for gas engines appears to be gradually taking the place of hot tubes and other non-electrical arrangements. The most common method of igniting electrically is to draw apart two electrodes in the combustion chamber, these two electrodes being normally in contact with each other, and carrying current from a battery in series with a sparking coil. At the right instant for ignition the electrodes are separated by means of a cam on the valve gear mechanism. Owing to the self induction of the coil this draws a spark sufficient to ignite the mixture of gas and air surrounding it. This is called the "wipe spark." Another but less common arrangement places the contacts outside of the cylinder where they can be more easily kept in good working order. These contacts are in the primary circuit of an induction coil, the secondary leading to contacts within the cylinder across which the spark jumps when the primary circuit is broken. This is called the "jump spark." An improvement on this arrangement is the use of a small magneto generator so designed as to give one impulse of current per revolution of the engine at just the right instant for ignition, thus doing away with all contacts, batteries, etc. A form of generator for this purpose was recently patented by Mr. B. McKinnerney. The parts of this generator are shown in Fig. 4. The permanent magnet is shown at a, and is made of the three horseshoes, 1, 2, 3, polarizing a number of laminations, d, which pass through coils, e, and terminate in pole faces, 4; c is a spoke of the engine which moves in the direction of the arrow. This one spoke carries an armature, b, which as the wheel revolves sweeps past the pole face, 4, magnetizing and then suddenly demagnetizing the laminations and setting up an electromotive force in the windings sufficient to jump the spark gap in the cylinder and ignite the gases. The patent claims merely a detailed form of construction, but is of interest through the principle of operation which it illustrates. Patent No. 638,933.

Enclosed Fuses.—When the fusible wire or strip of an enclosed fuse is closely surrounded by a large body of enclosing material the carrying capacity depends largely on whether this surrounding material is cold or is heated to a high temperature by a considerable current through the fuse. If the fuse consists of metals which form a thick oxide on the surface, or if it is surrounded by a tightly packed enclosing jacket of unsuitable material, it may be held in the molten form by the enclosure and conduct a current much greater than that at which it is rated. Mr. Joseph Sachs has designed a fuse intended to overcome these difficulties, which has been put on the market by the Johns Pratt Company of Hartford, Conn., under the name of the "Noark" fuse. Fig. 5 shows a longitudinal section of this fuse. It will be seen that the central part is enclosed in an inner tube of comparatively small diameter so that there shall not be at this point a large body of enclosing material capable of absorbing a large amount of heat and consequently retarding the fusion of the strip. This inner tube is stated to be preferably of glass. When the safety strip consists of lead or its alloys the contents of the inner tube may consist of borax or sal-ammoniac, as these materials act as a flux, combine with the oxide and tend to form non-conducting compounds with the fusible material itself when the latter is liquified by heat. To prevent the bursting of the outer tube upon the violent blowing of the fuse there is packed in each end of the outer tube a section of elastic or compressible material. Patent No. 635,395. The same inventor has also patented the combination of an enclosed fuse with a fine shunt fuse wire outside the enclosing case, the outside wire being designed to blow as soon as the enclosed fuse burns out, and thus to give an indication of the operation.

A Damping Device for Measuring Instruments.—A convenient form of foucault-current brake for rendering direct-current ammeter and voltmeter needles dead beat has been patented by Mr. F. W. Roller. The arrangement is shown in Fig. 6, as applied to a Whitney instrument The magnetic field used for the damping device is set up by the same permanent magnet which gives the constant field, which in turn combines with the field set up by the coil to give a deflection to the movable parts of the instrument. Part of the field of the permanent magnet is diverted by means of the pole-piece extensions, 9 and 10. Surrounding one of these extensions is a loop of conducting material, copper or aluminum, attached to the indicating needle, 12. As the loop swings this needle moves back and forth between the extensions, cutting the lines of magnetic force, which set up currents in the loop, tending to dampen the oscillations. Patent No. 636,182.

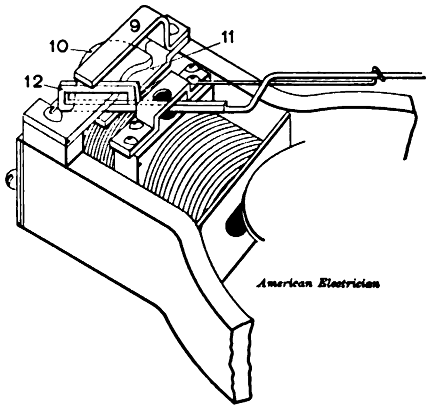

FIG. 6.—A MAGNETIC DAMPING DEVICE FOR INSTRUMENTS.

An Explosive Fuse.—The explosive nature of enclosed fuses on violent short circuits has generally been considered a disadvantage. Mr. Chas. P. Steinmetz, however, has patented a fuse in which the enclosing material is explosive in character and is depended upon to blow out the arc by the violence of its disruption when the fuse acts. The conducting strip itself, which is enclosed within this material, need not be fusible in character, since an enclosing material is specified which will explode at temperatures from 100° to 150° C. The operation of the fuse depends upon the heating of the strip to this temperature. The explosive material contemplated is one of several compounds of acetylene with metals in the form of metallic acetylides; the combination of acetylene with copper in the form of cupric acetylide ($C_2CU_2 + H_2O$) is mentioned as suitable. The patent claims are limited to the use of some acetylide. Patent No. 636,578.

An Arc Lamp Meter and Automatic Switch.—For indicating the time during which an arc lamp burns Mr. I. R. Prentice of the General Electric Company has patented the combination of a lamp mechanism and a clock, the escapement wheel of which is stopped by a brake, so connected with the clutch mechanism of the lamp that only when the latter is burning is the escapement allowed to move. A pawl is also connected with the clutch-moving mechanism and arranged to wind up the clock spring one tooth whenever the lamp feeds, thus making the mechanism self-winding. The patent also claims the use of a switch automatically operated by the clock to cut the lamp out of circuit when it has burned a suitable number of hours after trimming. Patent No. 637,825.

The Protection of Static Voltmeters.—The familiar electrostatic voltmeter or ground detector is a most convenient instrument for very high-tension circuits, as it contains no windings which in other instruments must be made very fine for high-tension work. Its use in the ordinary way, connected directly to the circuits, introduces considerable risk of short circuits or grounds, owing to the fact that the high-tension tends to spark across between the vanes which are necessarily close together in order to obtain forcible deflections. Mr. E. M. Hewlett, of the General Electric Company, has patented the use of a resistance in series with the instrument to prevent a short circuit in case the insulation of the instrument breaks down. This resistance can readily be made high enough to prevent the maintenance of an arc if the difference of potential jumps across the air gap in the instrument. The flow of current required by the instrument is simply that sufficient to charge the vanes electrostatically and is so small that the resistance has a very slight effect on the indications. This effect can be allowed for in the calibrations, or the resistance may be made sufficiently inductive to give the instrument full line potential by virtue of the leading currents set up by the capacity of the vanes. The whole arrangement is extremely simple and the wonder is that such broad claims could be obtained upon it as are in patent No. 637,785.

NOTES.

A Tale of Woe. — The following letter speaks for itself:

American Electrician:

Gents: We have an item of news for you. Our city has found natural gas and it is being sold for 20 cents a jet per month, no restriction at all, burn night and day. We have shut down and the town is dark. Will sell off our machinery cheap and quit the business.

Yours truly,
Chanute Electric Light & Power Co.
By G. W. Alcock, Supt.

A Fatal Electric Shock at an Unusually Low Voltage. — There is reported from Bradford, England, an apparently well-authenticated case of a fatal shock on a direct-current circuit carrying only 225 volts. The accident occurred to a workman who missed his footing on a trestle and, to save himself, seized hold of an arc lamp. The conditions were unusually favorable for a severe shock, as the man's wet boots and perspiring body gave an unusually low resistance path for the current.

An Improvement on the Coherer. — Prof. R. A. Fessenden and his assistant, Prof. Kintner of the Western University of Pennsylvania, claim to have discovered a receiver for wireless telegraphy that is many times more sensitive than the coherer of the Marconi system. The claim is made that the new receiver is 2000 times more sensitive, although what this figure is based on is not stated. Prof. Fessenden is reported as stating that it should be possible to send messages across the Atlantic with poles not more than 200 feet high.

The Convention of the N. E. A. — The eighth annual convention of the Northwestern Electrical Association will be held at the Hotel Pfister, Milwaukee, Wis., commencing on Wednesday, January 17. An exceptionally good programme has been arranged, and includes papers by Prof. Jackson of Wisconsin, Prof. Shepardson of Minnesota, Prof. Richter of Wisconsin, R. Fleming of Massachusetts, W. H. Schott of Illinois, H. W. Frund of Indiana, N. H. Dow of Michigan, and G. Van Ness of New York, all on subjects of practical interest to central station men.

Long Distance Transmission Scheme for Denver.—Arrangements are under consideration for a long distance power transmission from a central station to be located at Louisville, Colo., to Denver, a distance of 25 miles. Louisville is situated in the center of a lignite coal district and the purpose of the scheme is to save the cost of transportation on coal. It is also proposed to transmit power from this central station to the mines in Boulder, Gilpin and Clear Creek counties. The scheme includes the construction of an electric line from Louisville to Denver. It is estimated that energy can be transmitted to Denver at a cost equivalent to that of generating the same in Denver with coal at $2 per ton.

The Electric Equipment of the Manhattan Elevated Railway. — A few facts may be of interest concerning the enormous generators and rotary converters which have been ordered by the Manhattan Railway Company from the Westinghouse Company for running the elevated roads in New York City. The eight generators, rated at 6650 h.p. each, are the largest as yet ever designed, their external diameter being about 40 feet, while the rotating field and fly wheel will have a diameter of 32 feet. The weight of each machine and engine complete will be nearly 1000 tons. These machines will supply their current to 26 rotary converters, each rated at 2000 h.p. The generators will be driven by engines to be built by the E. P. Allis Company, which, in turn, will get their steam from Babcock and Wilcox boilers.

An Air Line Telephone Route.—The American Telegraph & Telephone Company is erecting a special long-distance line for the through service between New York and Boston. To avoid induction, the line will keep clear of all cities, railroads and even highways, following a private right of way practically the entire distance. It will be immediately equipped with 10 No. 8 copper wires and these will be worked with no intermediate switchboards, solely for the through traffic. No under river cables will be used, the line being carried across rivers overhead. In crossing the Connecticut River, for instance, the line will be carried on steel towers 185 ft. high so as to clear the tops of the highest masts that may pass under it.

Tests of Arcing Distances on Switches.—At the time of the last revision of the National electrical code, the regulations as to the construction of switches were made uniform for all voltages below 300 in order to avoid the greater number of classes and types of switches which would be caused by making separate specifications for 200 and 100-volt types. The requirements as to breaking distances, etc., necessary for 200-volt work led to difficulties in the construction of small fittings for 100-volt work where wide breaks, etc., are unnecessary. The Underwriters' National Electrical Association consequently is considering different specifications for the lower voltage. In order to determine just what limitation would be advisable, tests have been recently carried out, through the courtesy of the General Electric Company, at its works in Schenectady, to determine just what the proper breaking distances, contact surfaces, etc., for different rated current capacities should be.

A Proposed Meeting of the American Institute at the Paris Exposition.—It is proposed to hold a meeting of the American Institute of Electrical Engineers at the Paris Exposition during the coming summer, and informal negotiations have passed between the Institute and the Institution of Electrical Engineers in London, with a view of holding a joint meeting of the two bodies. The proposed date is during the week beginning August 13th, the opening session of the International Electrical Congress having been fixed for August 18th. Members of the Institute are asked to notify the secretary whether they are to be in Paris on the date given in order that an estimate may be made of the number who will be present, and the success which may be expected.

Arc Lights on 25-Cycle Circuits.— The Union Carbide Company illuminates the interior of its new works at Niagara Falls by means of enclosed arc lamps which, to avoid the use of running machinery, are connected directly to the 25-cycle system which supplies power for the carbide furnaces. Although 25 cycles can be used on incandescent lamps without noticeable flicker, arc lamps, owing, undoubtedly, to more rapid cooling of the carbons, have a very serious flicker at this low periodicity, but this was not considered detrimental in this case. The suggestion has been offered that where large areas are to be lighted from a number of arc lamps on a low frequency polyphase system, the arcs might be divided between the two or three phases, the flicker of those on one phase eliminating that of the others.

New Buildings for the University of Pennsylvania.—The University of Pennsylvania is in receipt of a gift of $250,000, to be used for the building and equipment of a laboratory of physics. The building will be located on Thirty-fourth street facing the library, and will be within about 500 feet of the college buildings and the same distance from the Harrison Laboratory of Chemistry. This will add needed facilities both for undergraduate and graduate work and strengthen the courses in engineering, as well as in pure physics. The completion of the building will see a largely increased staff. The University has now under construction, or in the hands of the architects, buildings valued at over a million dollars, including a new law school costing $350,000, addition to the dormitories valued at $250,000, a new medical laboratory costing $500,000, in addition to the new building for physics. The formal opening of the Free Museum of Science and Art took place on December 20th.

Transformation of Phases Without Change of Voltage.— The Niagara Power Company has installed a pair of transformers unique on account of the fact that they change the number of phases of the power passed through them without any change whatever of the pressure. The transformers are rated at 500 kw. each and are designed to supply some three-phase 2200-volt loads on the Canadian side of the Niagara River which were previously supplied from machines belonging to the same company but located in the power house of the Niagara Falls Park & River Railway Company which burned some months ago. This load will hereafter be supplied from the large 2200-volt two-phase power plant on the New York side of the river, requiring, therefore, a transformation from 2200 volts two phases to 2200 volts three phases. The two transformers are, of course, Scott connected on the secondary sides. One, the main, has a transformation ratio of 2200 to 2200, while the other, the teaser, has a transformation ratio of 2200 to 1900.

A Substitute for X Rays. — Years ago Bequerel found that salts of the rare metal uranium possessed the power of throwing off a feeble and invisible radiance that affected photographic plates, like the X rays. Mme. Curie in Paris last year isolated from the Bohemian mineral pitchblend two other elements that behave in the same manner, but are far more active. One of them she called "polonium" and other "radium." The latter is said to be one hundred thousand times as intense as uranium in its photographic effect.

Prof. Geo. F. Barker, of the University of Pennsylvania, has been experimenting with all three of these elements and with the mineral (pitchblend or uranite) from which the two new elements are derived. He recently exhibited a series of photographic plates on which impressions had been produced by these substances. His procedure has been as follows:

A photographic plate was inclosed in black paper and then covered with yellow paper. After one whole day's exposure to the sunlight no effect was produced. This precaution proved the thoroughness of the protection. Then the various metals and salts were placed outside the covering of the plate and they produced dark stains.

In order to take photographs of objects such as a hand or foot these objects would be placed between the metal and the plate, and the result would be similar to those obtained by the X rays. Such substances as bone show clearly through the flesh and surrounding tissue. A photograph can be taken by means of radium in half a minute.

The property of the new metal is apparently of great practical value. The results of the X rays, now so useful in surgical diagnosis, can be duplicated by a method much cheaper. Radium seems to suffer no diminution of energy or loss of weight during the process. In addition to producing an impression on the photographic plate, radium produces phosphorescence and discharges electrified bodies. Thus it will be seen that it possesses all the qualities of the Röntgen rays.

Radium apparently violates one of the fundamental laws of physics, namely, that of the conservation of energy. It does not appear to derive its photographic power from the sunlight nor lose it by expenditure.

Simultaneous Telephony and Telegraphy.— In a paper read before the annual meeting of the Railway Telegraph Superintendents' Association by Mr. Charles Selden, an account was given of some experiments carried on about 14 years ago on the lines of the Baltimore & Ohio Railroad & Telegraph Company with the Van Rysselberghe system, which account may be of interest in connection with the article on which recently appeared in the American Electrician, explaining the various methods of carrying telegraph and telephone messages simultaneously on the same wires. From Mr. Selden's paper the following sections have been extracted:

Our service at that time contained few or no copper wires, and we were limited, therefore, to the use of iron for the purpose of our experiments.

The experiments were perfectly successful, and commercial conversation was carried on between Baltimore and Cumberland, Md., a distance, as the wires run, of about 195 miles.

When we reached Grafton, W. Va., and made experiments from that point (which added to the distance so that it became 300 miles), the talk ceased to be "commercial." It was possible and successful to a certain extent, but that was all.

Proceeding further to Parkersburg, W. Va., now a distance of 405 miles, the difficulties became so much enhanced as to render the talk unintelligible.

As the company had copper wires extending from New York to Fostoria, Ohio, we moved our outfit to that point, and, not knowing what effect the various other wires within the city of New York, the cables across the Hudson River and other extraneous paralleling on the part of other systems might have, it was decided to make an experiment from Fostoria to Coeymans Station, N. Y., and Mr. Wm. Maver, an eminent electrician and electrical author, took charge of the experiments in person at that end of the line. The first test was made on copper wires —the gage of which I do not remember— at 4 o'clock in the morning, and I can still see in my mind's eye the delighted expression upon Professor Van Rysselberghe's face as its success was most pronounced.

Arrangements were then made with another company to, for a few days, trade some iron wires for copper, from Fostoria to Chicago, so that a test could be made from the Chicago to the New York terminal.

In Chicago the apparatus was placed in a room of the Palmer House on Wabash Avenue, and in New York in a room of the building No. 63 Broadway.

The results of the experiment were eminently satisfactory, and my recollection now is that telephonic communication was carried on over two wires, at the same time that those wires were being operated for quadruplex telegraphing,

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Publishers' Announcement.

Subscribers are hereby notified that Charles W. Nonnamaker is no longer connected with, and is not authorized to take subscriptions or make collections for the American Electrician.

The Compliments of the Season.

To the subscribers and other readers of the American Electrician, as well as to all connected with the electrical industries, the American Electrician wishes a prosperous and happy New Year. The prospects of the realization of this wish on the part of the electrical industries in general were never more promising. Of the general tide of prosperity now advancing, the electrical and allied fields form the highest waves. The statement is probably true that never before was there a greater demand upon the whole line of manufacturers of apparatus for a widespread industry than there is now upon the manufacturers of heavy steam and electrical machinery. New undertakings of such magnitude that a few years ago they would have been derided as imaginary, promise a continuance of this demand.

Pioneer Work at Niagara.

On account of the large size of the generators, as well as the loads carried by the Niagara power system, the engineers in charge of the work have been obliged to solve many peculiar difficulties which had never arisen before that unique installation was undertaken. The same problems will arise with even more difficult conditions in many still larger undertakings of central station and traction interests, some of which are already under way in New York City. The engineers of these proposed works have much to learn from the experience gained at Niagara Falls.

One of the most interesting directions in which this pioneer work was necessary was the protection of the lines against over-loads and short circuits. In low-voltage work when the magnitude of the current in use becomes so great that automatic circuit-opening devices become troublesome—as in large metropolitan three-wire systems—they are simply abandoned and short circuits are allowed to burn themselves out. This cannot be done when the pressure is several thousands of volts. In low-voltage work extensive, tree-like, branching ramifications of the circuits are protected by fuses, which become smaller and smaller in size as the lines branch out into smaller and more numerous branches. The melting of these fuses requires a certain continuance of the flow of current, longer for the large fuses than for the small ones; which prevents a short circuit on a small branch from opening all the fuses between it and the central generating plant. With circuit breakers—which are necessary in high-tension service—a short acts practically instantaneously upon the tripping mechanism of all the breakers through which its current flows. To avoid this there must be introduced a time-element arrangement introducing more and more lag as the generating station is approached. Unfortunately, with alternating-current synchronous motors, including rotary converters, this introduces another trouble due to their liability to break out of step if a short remains upon the system for a few seconds while a time-element breaker is waiting to open.

The reverse-current arrangements (which—with those mentioned above—are described on other pages of this issue), and which are designed to cut off one of two parallel lines of transmission in case of failure, leaving the other in operation, are also of great interest owing to the need of some such arrangement to assure continuity of service on large systems in spite of faults of the transmitting parts. The only criticism that can be made from an outside point of view upon the devices of this nature at the Falls is the necessity with alternating-current apparatus of taking into account the relative alternations of the current and of the waves of e.m.f. in order to determine whether the alternating-current is reversed or not. In case a short circuit absolutely wipes out all difference of potential between the legs of the circuit the apparatus becomes inoperative.

Of the general success of the application of Niagara power from an electrical and mechanical standpoint, there are no better evidences than the rapidly increasing growth of the demand as indicated by the yearly load curves on page 5, and the inability of the company to supply all the loads which it could obtain within the next year or two before the new generating plant is erected. The rapidly increasing load is also a surety of financial success in a case of this kind, where the greatest expense is the fixed charges on the large original outlay which has to be incurred regardless of whether the load is small or large.

The Cost of Arc Lighting.

Now that so many different systems of operating arc lights are offered in place of the old troublesome and wasteful small series machines driven through counter shafting, such a thorough analysis of the relative costs of the different systems as that recently presented by Mr. H. H. Wait before the American Institute of Electrical Engineers, and reprinted on other pages of this paper, is of great value. In the majority of instances, however, the question of costs brings in other elements that could not be thoroughly discussed in less than book form. Mr. Wait's assumptions as to the different arrangements that he compares are that they are all small stations of the same size. In many instances the arc service may be part of a large central station system using, let us say, large direct-coupled, alternating-current units with a high steam economy, low first cost per kilowatt and small depreciation. In such cases the running of the arcs by power derived from these large generating units instead of by the comparatively smaller engines which are required for engine-driven arc dynamos would show up much more favorably than under the conditions in Mr. Wait's tables.

Another element that these tables do not bring out quite as strongly as it should be emphasized is the improvement of the incandescent service due to throwing the arc load upon the incandescent dynamos, either by means of constant-current transformers in the case of alternating systems or motor-driven arc dynamos in the case of either alternating or direct-current systems. The increased load and consequent larger size of the engine and dynamos give a lower cost per horse-power of both engines and generators and improved steam economy and electrical efficiency. The load factor and steadiness of the load are also improved. These factors may change considerably the advantages which the tables show for engine-driven arc dynamos.

Concentric Cables.

For low-tension three-wire distribution the so-called Edison tube, consisting of an iron pipe containing three round copper rods insulated with asphaltum, seems to have seen its day. Lead-covered cables with paper insulation and stranded copper cores, drawn into conduits, are now being used almost exclusively for feeders and to a large extent even for mains where the ease of tapping off service branches from Edison tubes gave the advocates of the tube system a final stand. The reasons for this change of practice are several. The asphaltum of the tubes has an annoying trick of softening under heavy overloads and allowing the conductors to come together, causing a short, or fall to the bottom of the tube, causing a ground. When the conduit is laid the lead-covered cable is more flexible and more easily renewed or repaired than are the tubes which require an excavation for every change. The perfection of paper insulation has materially reduced the cost of the cable.

In early underground practice each conductor was separately lead-covered, several such small cables being drawn into one duct. This is obviously most wasteful, both of duct space and of lead, since one single lead-covered cable filling the whole duct, would not only contain less lead but would give much more available room inside the sheathing for insulation and conductors. For series arc-light circuits, four, six, or eight conductors are now often combined within one lead sheathing. For high-tension three-phase work three conductors are customarily enclosed within one sheath in the clover-leaf form of three round cables with what is termed "split insulation," and jute fillers to preserve a circular contour of the lead. For low-tension three-wire work this arrangement is available wherever each single conductor is insufficient in size to fill a whole duct, but in cases where high conduit rentals must be paid or for any other reason it becomes desirable to get as much copper as possible in the ducts, this arrangement is rather wasteful of space within the cable sheath.

At least one company in this country, the New York Edison, as noted upon another page, has adopted a concentric arrangement. The cables used are not triple concentric, like those the details of which have been brought to such a high stage of perfection in England, and which are now generally used there, but are double concentric, carrying the positive and negative sides of the system, the neutral being a single-conductor cable carried in another duct. This arrangement only half solves the problem, as it requires the use of one small single-conductor cable which is wasteful of duct space unless the neutral is made a trunk for several + and — double concentrics. In this case the concentrics might better be divided into a smaller number of feeders with larger cross section each and run in the form of single-conductor cables, each filling a duct.

It is a pity, now that grounding the neutral bids fair to be openly adopted and recommended, that the cable sheath itself could not be used as the neutral and made of some material with a high conductivity and a flexibility comparable with that of lead; possibly aluminum might serve for this purpose. There would be no danger of electrolysis as the drop in the neutral is very slight and constantly alternates in well-balanced systems from one direction to the other, the current flowing at times toward the generating station and at other times away from it.

Steam Pipe Slope.

The vexed question as to which way to slope the steam pipe from a boiler to an engine in order to obtain the best drainage seems to be always open to argument. In the simple case of a single line of pipe direct from the boiler to the engine modern practice favors a slope downward in the direction in which the steam flows. If the slope is backward toward the boiler the flow of steam retards the drainage of water since the two are in opposite directions in the pipe. At some restricted point, such as a bend or a valve (especially if the latter is not straightway or is partly closed) the velocity of the steam is likely to be so high in case of an overload that the water cannot flow back against it. Overloads also cause priming so that drainage at such times is particularly necessary. The water held back by the restriction gathers in the pipe until it chokes it so much that suddenly it is all swept forward toward the engine and unless an ample receiver separator is used causes a broken cylinder head. With the slope toward the engine the drainage is assisted by the flow of steam and the water is taken up by the separator, which should be located as near the cylinder as convenient.

In the case of more extensive systems using headers, the conditions become a little more complicated, and it is customary to make all branches from the boilers and to the engines drop into the header, draining the header by means of gravity back to the boilers or by the steam loop. In this case it is undoubtedly just as well to make the runs from the header to the engines slope back toward the header provided they are of ample size for any overload and are not restricted at any points by very sharp bends or badly designed valves.

DESIGNS FOR SMALL MOTORS.

ONE-H.P., FOUR-POLAR MOTOR WITH DRUM ARMATURE.

BY CECIL P. POOLE.

For the four-polar one-h.p. motor here described only one type of field magnet is shown, namely, the familiar ring yoke with radial magnet poles. This type combines more good points than any other, hence the limitation to the one type. A choice is given, however, between cast-iron and cast-steel. Fig. 1 shows the cast-iron magnet frame and Fig. 2 the cast-steel frame. Fig. 3 is an edge view of either frame and Fig. 4 is a plan view. The cast-iron machine will be found easier to make because there is less tooling to be done and iron castings are smoother than steel, requiring little or no finishing elsewhere than the pedestal seats and pole faces.

The measurements for the cast-iron magnet are as follows:

A—Bore of armature chamber	5⅝
B—Radius to which pedestal seat is bored	5½
C—Outer diameter of yoke ring	13
D—Distance between parallel inner faces of yoke ring	10
E—Width of plane surface behind coil	5
F—Width of magnet core	2½
F_2—Breadth of magnet core	4
G—Distance from core to angle of yoke	1¼
H—Width of frame foot	2
H_2—Length of double foot	4½
J—Width of pedestal lug and seat	3
K—Length of pedestal lug commutator side	5¾
L—Length of pedestal lug pulley side	3¼
k—Length of pedestal seat	3
M—Axial width of magnet yoke	7

Fig. 5 shows the cross-section of a magnet core, from which it will be seen that the corners of the core are rounded off. The radius of the curve here is ¼ inch. The only machining that should be required for this frame is boring the armature chamber and pedestal seats and drilling 12 bolt-holes. The frame should be clamped to a lathe carriage with its center true with the lathe centers, and the boring done at one setting by means of a boring bar and tool. Both pedestal seats should be cut before the frame is moved from its original position.

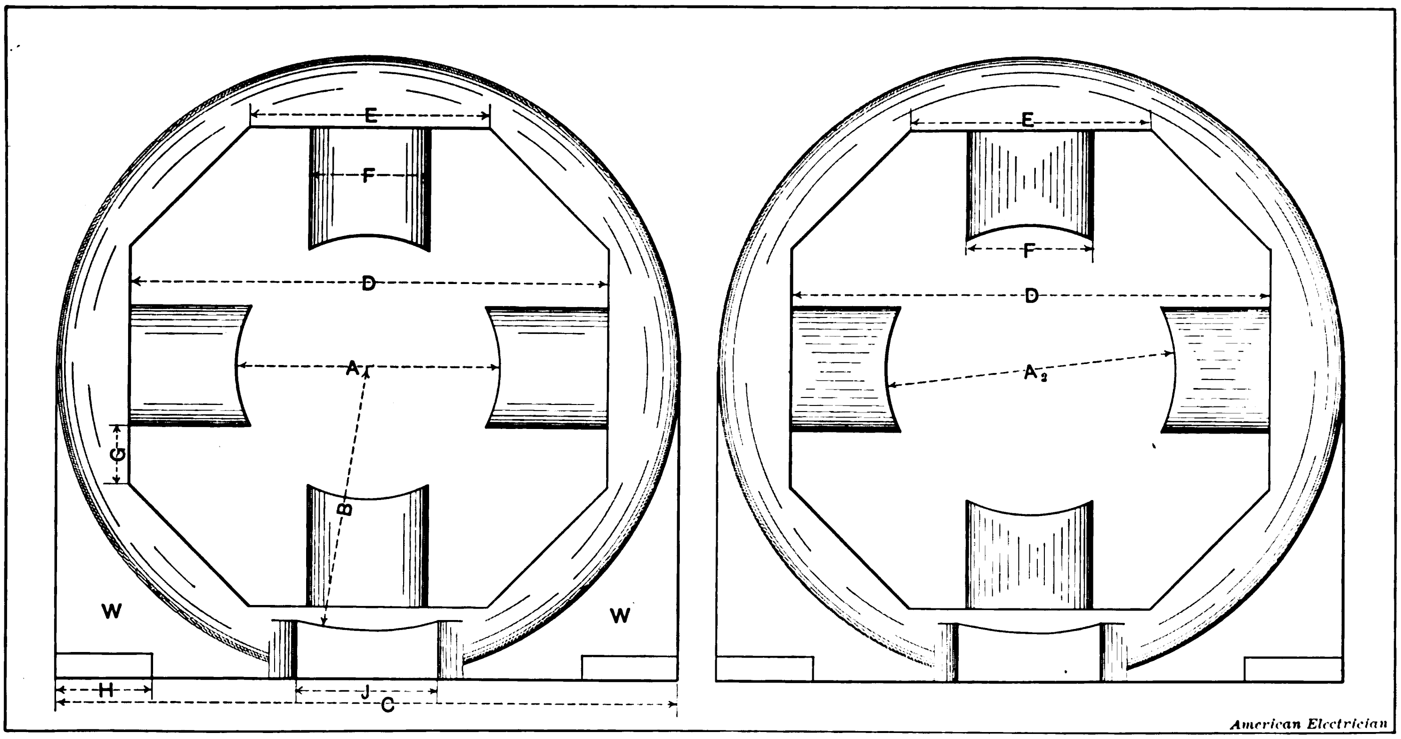


FIG. 1.—END ELEVATION OF MAGNET FRAME MADE OF CAST IRON. FIG. 2.—END ELEVATION OF MAGNET FRAME MADE OF CAST STEEL.

These and the following drawings accompanying this article are drawn to scale and reproduced ¼ full size.

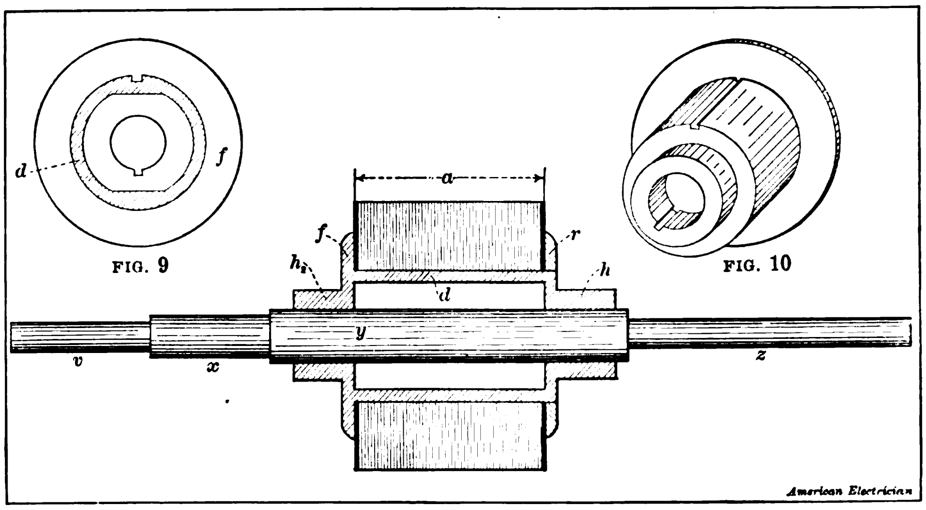


FIG. 8.—SECTION THROUGH ARMATURE SPIDER AND CORE DISCS.

The magnet must be made of the very best grade of iron obtainable; use Scotch pig if possible. It should be allowed to remain in the sand until it is cold, care being taken not to remove any of the sand around the magnet portion until the casting is ready to come out. The longer of the two lugs might advantageously be placed uppermost in putting the pattern in the sand, and after the casting has been cooling for 24 hours the sand may be scraped away from the end of this lug so that its temperature may be noted.

Fig. 8 shows the shaft and a cross-sectional view of the armature core. The discs are mounted on a cast-iron drum, d, which has a flange, f, and a hub, h₂, at one end, and a hub, h, at the other end. Fig. 9 gives a transverse cross-sectional view of the drum, and Fig. 10 is a perspective view, from the flangeless end. The wall of the drum is thickened at two places, diametrically opposite, as shown in Fig. 9. This is necessary on one side in order to provide sufficient metal under the keyseat; it is necessary on the opposite side to obtain a mechanical balance.

The discs are held endwise by a clamping ring, r, which may be either screwed onto the end of the drum, d, or held on by four flat-headed screws with large heads. The discs are held from turning by a key. At each end of the magnetic core a disc of fibre, indicated by heavy black lines, should be placed. These discs must be exactly like the iron discs, except that they are 1/16 inch thick.

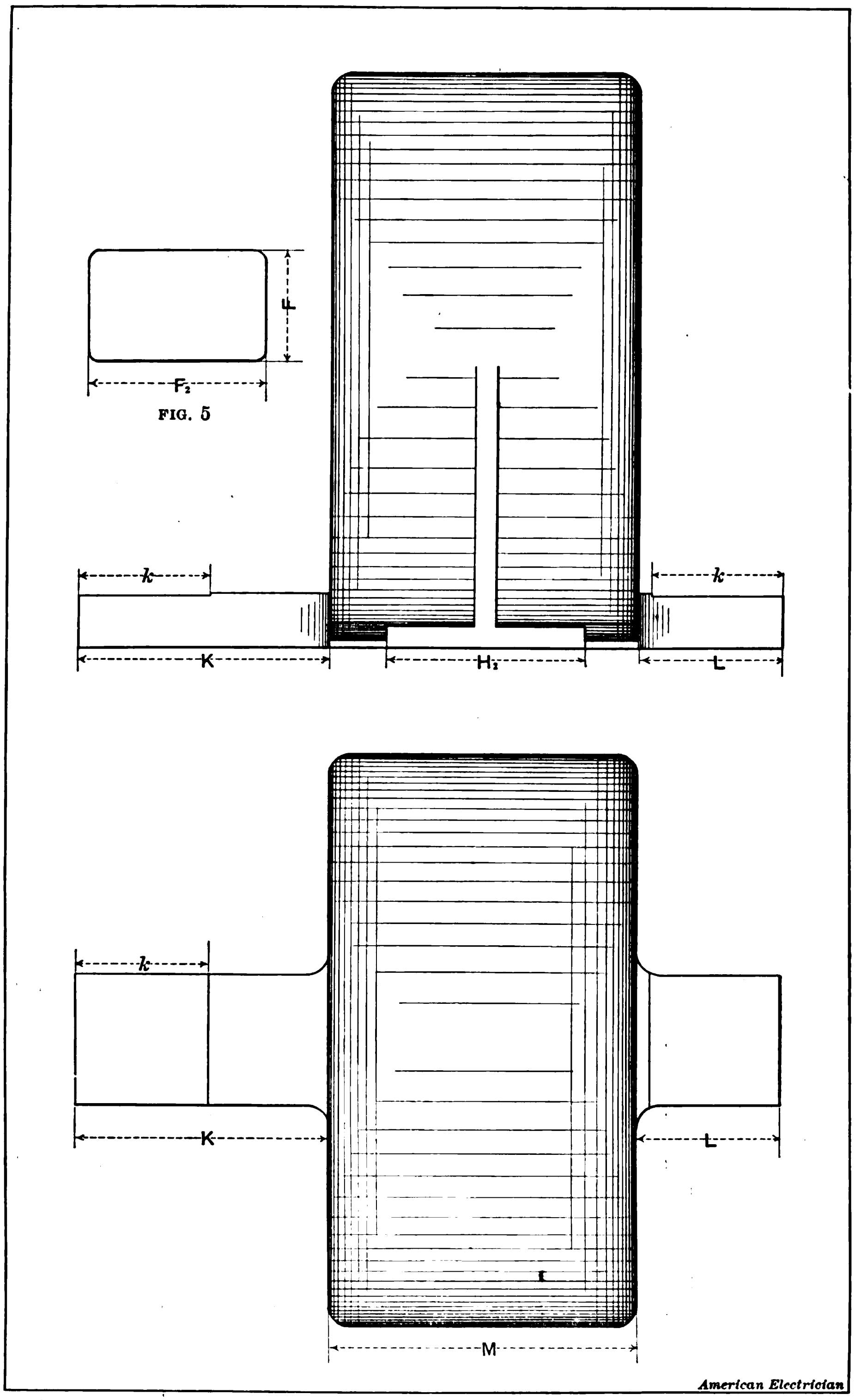
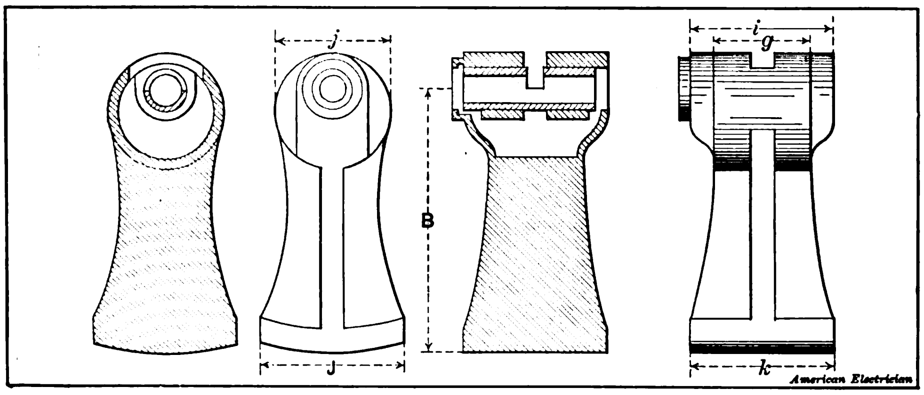


FIG. 5

FIGS. 3 AND 4.—SIDE ELEVATION AND PLAN OF FIELD MAGNET.



FIGS. 11 TO 14.—VERTICAL SECTIONS AND ELEVATIONS OF PEDESTAL.

The iron core discs are 5½ inches in diameter and 1/40 inch thick, with 32 slots, each ¼ inch wide and 9/16 inch deep. The slots have parallel sides. The discs must be of the best charcoal iron; the hole in the center is 3 inches in diameter, keyseated. The flange, f, and the clamping-ring, r, must have their outer edges rounded off to avoid cutting the insulation of the winding. The dimensions of the core drum are as below:

	Inches.
Length of drum, d	4¼
Inner diameter of d	2½
Outer diameter of d	3
Diameter of flange, f, and ring, r	4⅜
Thickness of flange, f, and ring, r	¼
Thickness of d at thickest point	½
Diameter of hubs, h and h_2	1⅞
Bore of hubs, h and h_2	1⅛
Length of hub, h	1¼
Length of hub, h_2	1
Length, a, of disc portion of core	4

The shaft measurements are as follows:

	At v	x	y	z
Diameter, inches	⅝	⅞	1⅛	⅝
Length, inches	3	2½	7½	6

The shoulders where v and x meet and where y and z meet should be slightly rounded off at the corner and filleted in the angle. A key should be used to fasten each hub to the shaft, but the machine will doubtless give satisfaction with only one key, that one being in the hub, h, at the pulley end.

Figs. 11 to 14 inclusive show end and side views and cross-sections of a journal pedestal and box. The two bearings are alike in every particular, and are made of cast iron. The base or foot is tooled to conform to the circle to which the pedestal seat, on the magnet frame, is machined, and is ½ inch thick. The standard or pedestal consists of two ribs at right angles to each other, ½ inch thick and having curved edges, as shown. The box is of the ring-oiling type, with a single ring hung about midway of the journal; the bushing is easily made from thin brass tubing, ⅞ inch outside diameter, and with a very thin wall (not over 1/32d inch), babbitted to fit the shaft and having a slot ⅝ inch wide cut half way through it, nearly midway between its ends; accurately, the slot must be ¼ inch nearer one end than the other. The bushing is 2¾ inches long; the oil ring is made of brass, 1½ inches in diameter, inside, 1 11/16 inches diameter outside, and ¼ inch wide along the shaft. Reference to the side views of the journal pedestal will show a slot in the upper wall of the box portion, through which the oil ring is inserted before putting in the bushing. A cover should be provided for this slot to keep out dust, etc. The dimensions of the journal pedestals are as follows:

	Inches.
B—Radius of arc, pedestal seat	5½
g—Length of circular oil reservoir	2
i—Length of journal box	3
Bore of journal bax	⅞
j—Diameter of oil reservoir	2⅜
Internal diameter of oil reservoir	2
J—Width of pedestal foot	3
k—Length of pedestal foot	3

The bore of the box portion of the pedestal must, of course, be made to fit snugly the outer diameter of the tubing used for a bushing, as the wall of the latter is too thin to admit of turning it down to fit a predetermined bore in the pedestal. After boring the pedestal to fit the

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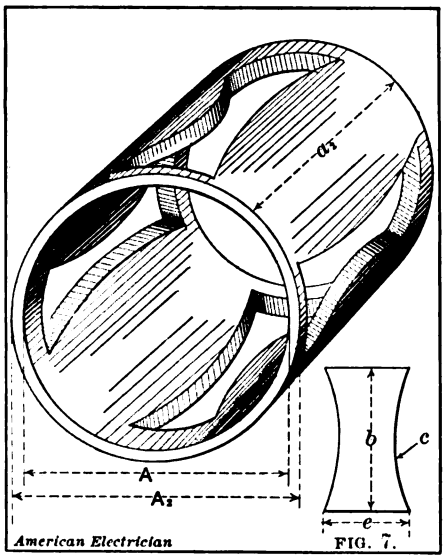


FIG. 7.

FIG. 6.—BUSHING FORMING POLE PIECES FOR USE WITH STEEL FRAME.

bushing it should be mounted on a mandrel and its base turned to the radius B, of 5½ inches, which is the same as the radius of the circle of the foot on the magnet frame. Each pedestal should be fastened to the foot with four ¼-inch cap screws.

Of the two field magnets shown, the steel one is much preferable if the reader has the skill and facilities to make it properly. The difference from the cast-iron magnet consists in making the magnet cores round instead of oblong, and putting on pole-shoes. The length of the machine is thereby reduced one inch, but all the transverse measurements remain unchanged. The magnet ends are machined, exactly as in the case of the cast-iron frame, but the bore, A_2, is greater, namely, 6⅛ inches.

The pole-pieces are made in one piece, called a polar-bushing, like Fig. 6, and this had better be done before the magnet is bored out. This bushing is a simple cylinder of cast-iron with four openings in its wall, equidistant from each other. Fig. 7 shows the exact shape of each of these openings. The measurements of the bushing are these:

	Inches.
A—Bore of bushing, finished	5⅝
A_2—Diameter of bushing, finished	6⅛
a_2—Length of bushing, finished	3¼
b—Length of openings in wall	3
c—Radius of curve, side of opening	4
e—Maximum width of opening	1¾

The casting for this bushing should be about 3⅝ inches long, 6⅜ inches in diameter and 5⅜ inches bore, in the rough. After it has been turned down to the finished diameter, mount the magnet frame and bore out its polar circle to such a size that the bushing is a snug fit—not quite a driving fit, but tight enough to prevent turning by hand. Then insert the bushing so that the openings in its sides come half way between the magnet cores, and scribe the outlines of two opposite cores on its surface.

Remove the bushing and set a steel pin at each extremity of each ellipse scribed on the surface. Then put the bushing back and bore it out for the armature chamber. The pins will take up against the edges of the magnet cores and prevent the bushing from turning. After boring it out, turn off the ends of the bushing so as to leave the connecting webs from pole-piece to pole-piece ⅛ inch thick.

The objection to this magnet is the difficulty of fitting the bushing to the magnet with sufficient accuracy to make good magnetic contact and still leave it loose enough to permit removal without breaking the thin connecting webs. This could be obviated by bolting the pole-pieces to the ends of the magnet cores by means of long, slender machine screws, put in from the outside of the yoke through holes in the centers of the magnet cores. Then the connecting webs could be sawed out entirely, leaving each pole-shoe independent of the others. This construction is also magnetically preferable, and if the builder has means for drilling a ¼-inch hole from the outside of the ring to the end of the magnet core (a distance of 3⅛ inches), the pole-shoes should be held on this way.

With the steel magnet the following measurements must be substituted for those previously given:

	Inches.
F—Diameter of magnet core	2⅝
M—Width of magnet yoke	6
a—Length of disc part of core	3
Length of drum, d	3¼
Outer diameter of drum, d	2¾
Inner diameter of drum, d	2¼

The windings for these machines will be given in the next article.

INTERIOR WIRING.

BY CHARLES E. KNOX.

PANEL BOARDS.

The first panel boards which were used were designed with all the connections at the back of the panel itself. This method had many disadvantages. First, the connections were inaccessible, and in case of "trouble" or when changes were to be made, it was necessary to remove the entire panel in order to reach the connections. Again, short circuits were very apt to occur owing to the fact that as the connections were unseen they were more than likely to be badly made and badly protected.

Then came the panelboard with front connections. When these boards were adopted the difficulty arose of finding a suitable method of bringing the wires to the proper point for connection. Up to this time (and particularly with the back connection panelboards) the usual method adopted was to end the conduit (if any were used) within two or three feet of the panel and to cross the wires in the most convenient manner back of the panel and thus bring their terminals to the proper point for connection. A prominent

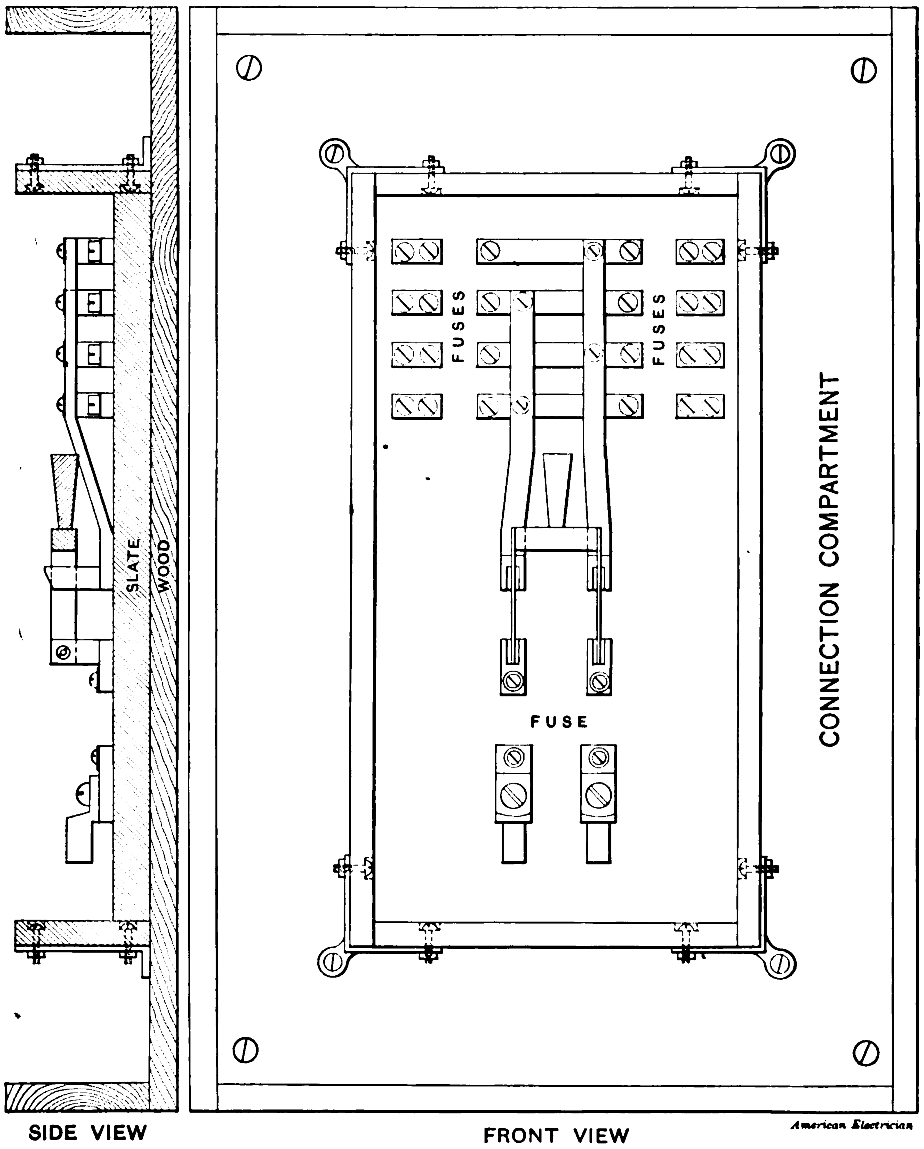


FIG. 1.—A TYPICAL MODERN PANEL BOARD.

New York electrical engineer, at that time, designed a cabinet with an outer compartment, such as was shown in the last article of this series. This method of making the connections was then adopted and is still in use at the present time.

The panelboards of both the front and rear connection type were arranged with bus bars running vertically up and down the panel, with cross-connecting bars, extending horizontally across the panel to both edges of the panel for the branch circuit or main connections. These horizontal bars were cut or interrupted for the insertion of fuses. These fuses were not of the plug type, as had been in use with the cut-outs on porcelain fuses, but were of the link type, i. e., they consisted of pieces of fusible metal provided with copper or brass terminals. In cases where the wire to be connected to these bus bars was larger than No. 8, special copper lugs were provided for the purpose; the wires being inserted in a hole in the lug and then soldered, or, to use the wireman's terminology, "sweated" in place. This was a marked step in advance over the method used in the porcelain base fuse blocks, where large wires were squeezed under screws and where, in many cases, only a portion of the wire made actual contact.

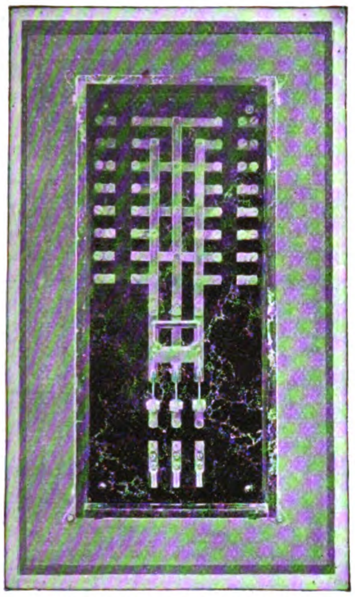


FIG. 2.—SHOWING PANEL BOARD MOUNTED WITH SLATE AND WOOD BOX AND CONNECTION COMPARTMENT.

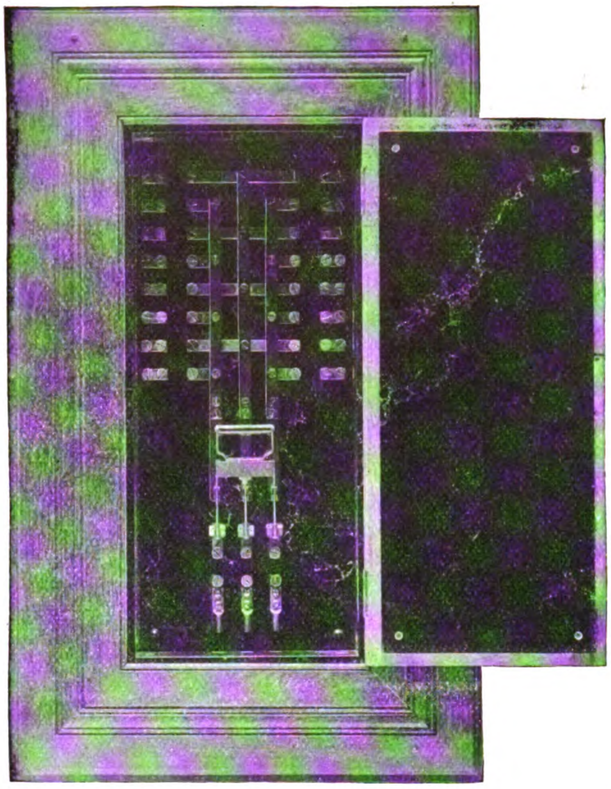


FIG. 3—BRANCH CIRCUIT PANEL BOARD INSTALLED IN DOUBLE CUT-OUT CABINET.

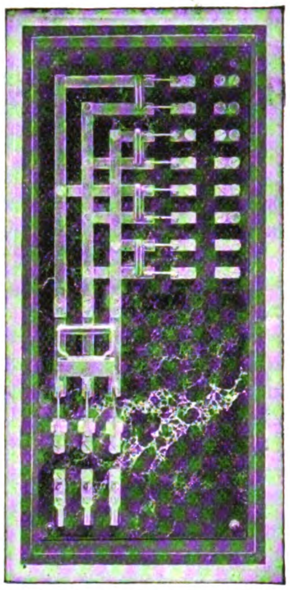


FIG. 4.—SHOWING PANEL BOARD MOUNTED WITH SLATE AND WOOD BOX BUT NO CONNECTION COMPARTMENT.

Fig. 1 shows a design of a panelboard that is used to a great extent at the present time. As the drawing shows, this consists of a slab of slate or marble, on which are mounted two vertical bus bars (the design shown being adapted for the "two-wire" system) with short horizontal bars for the branch circuit connections. In this case provision has been made for the feeder or main coming in at the bottom of the panel. Lugs have been provided for making the connection to the feeder or main. A knife switch has been placed in the circuit so that the branch circuits may be cut off from the main circuit in case it be desired to do so; the connection between the main and the knife switch is made through link fuses. Provision has also been made for link fuses in the branch circuit connections, but no switches are provided.

This panelboard is enclosed with sides of slate or marble, which may vary from ⅜ to ¾ inch in thickness, depending upon whether slate or marble is used and also upon the size of the panel. If marble is used it should be thicker than slate for the corresponding size of box, as slate is stronger. The slate sides are held in place by skeleton angle frames placed at the four corners. The entire outfit is mounted in a wooden box, allowing a space of about three or four inches between the outside box and panel, for carrying the wires to the proper points.

Fig. 2 shows a cut of a panelboard similar to the one shown in the drawing. Fig. 3 shows the panelboard installed in a complete cabinet, with door. It will be noticed that the door opens only on the panel itself, the connection compartment being enclosed by the cabinet "trim."

Fig. 4 shows a type of panel mounted in a wood box lined with slate. It will be seen from the cut that there is no connection compartment provided for this panel. This type of cabinet is called "single;" those having connection compartments are called "double" cabinets. Comparatively few of the former type are now used.

The panels shown in Figs. 1, 2, 3 and 4 are all provided with lugs for the incoming feeder or main. The connection between this main and the branch circuits is made through a knife switch provided with fuses. It will be noticed that the fuses are shown below the switch, i. e., nearer the source of supply. It is questionable if this is better than having them placed above the switch. Of course when they are placed as shown the switch is surely protected from "short circuits," but this arrangement makes it difficult to replace these fuses in case they "blow." If the fuses were placed above the switch the current could then be thrown off when it became necessary to replace a fuse. With this arrangement the switch would only be unprotected in case a short circuit occurred between the fuses and the switch, which, owing to the short distance between them, would be very unlikely. Besides the switch would probably be protected from even this possibility by fuses further along the line, nearer the source of supply.

It will be noticed, also, that the switch is hinged at the bottom, with the handle above. This is done to conform with the wise requirement that "all switches must be mounted so that they will tend to open rather than to close by gravity."

It will be noticed that in Fig. 4 all the branch-circuit connections are located on one side of the panel. This is frequently done in cases where all the circuits enter the cabinet on one side. The knife switches here shown are known as "baby" knife switches, designed for use on branch circuits.

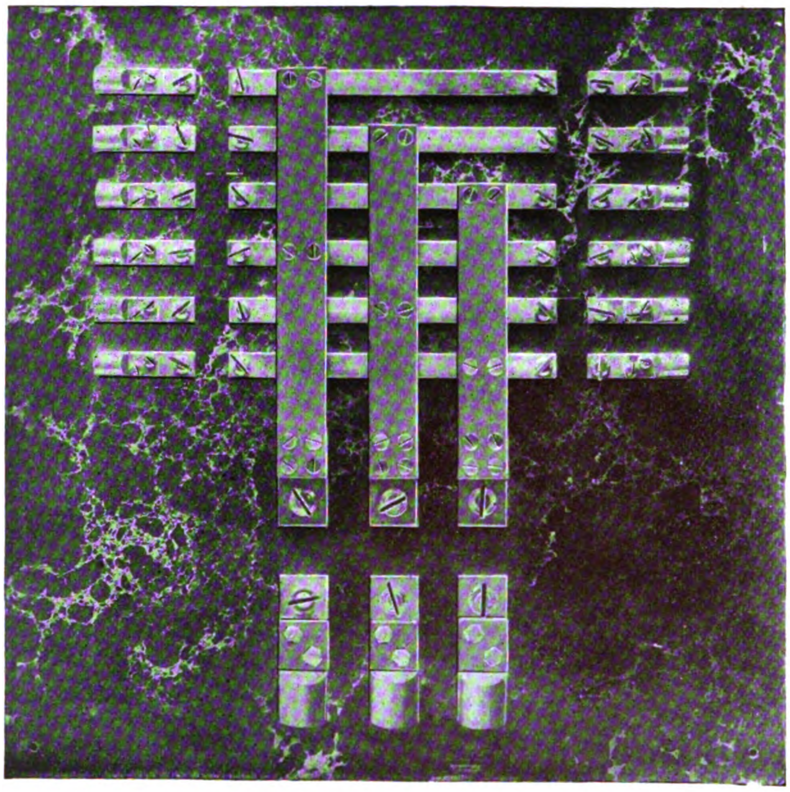


FIG. 7.—FEEDER AND MAIN PANEL BOARD WITH FUSE CONNECTIONS FOR FEEDER AND MAINS.

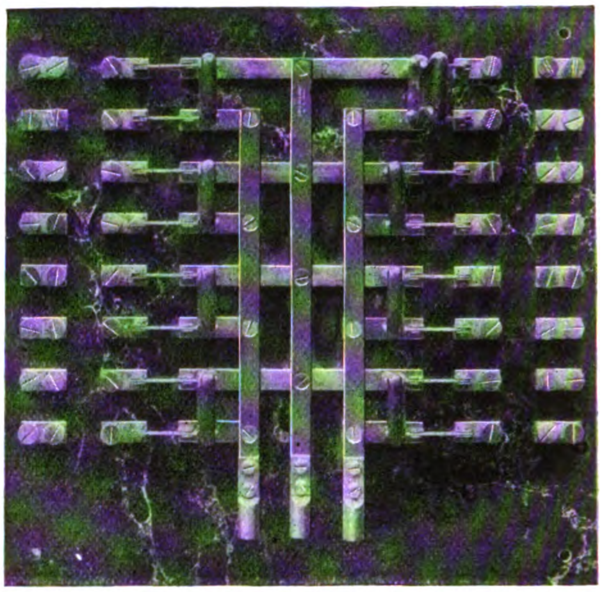


FIG. 6.-FEEDER AND MAIN PANEL BOARD WITH KNIFE SWITCHES AND LINK FUSES.

The use of these knife switches is not objectionable where they are only used for the purpose of opening the circuit to replace a fuse, but they are not recommended for the purpose of control, as in the latter case they sometimes fall into the hands of inexperienced parties and trouble ensues due to repeated opening under load.

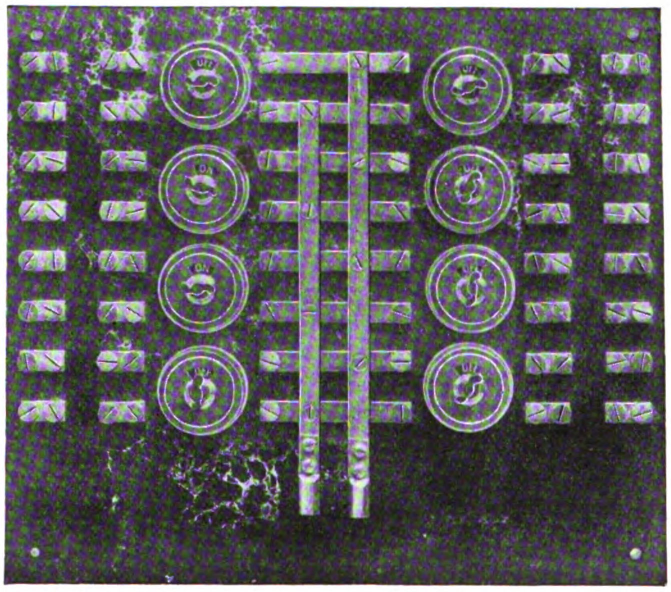


FIG. 5.—BRANCH CIRCUIT PANEL BOARD EQUIPPED WITH SNAP SWITCHES AND LINK FUSES IN BRANCH CIRCUITS ONLY.

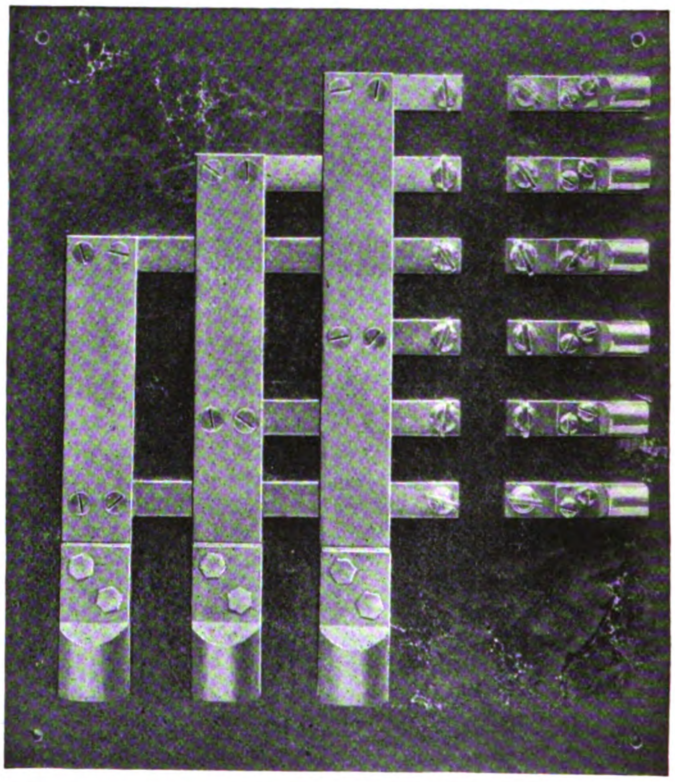


FIG. 8 —FEEDER PANEL BOARD WITH NO FUSES ON INCOMING FEEDER OUTGOING FEEDERS ARRANGED ON ONE SIDE AND PROVIDED WITE FUSES.

Fig. 5 shows a design of panelboard where snap switches are used to control the branch circuits. The only objections to this arrangement are the increased cost and the increase necessary in the width of the panel.

Fig. 6 shows a design of panelboard which is provided with lugs for the incoming feeder, but without fuses or a knife switch to disconnect the feeder from the panel. Each of the branch circuits is provided with a knife switch and fuses. This panel (as are also those shown in Figs. 2, 3 and 4) is adapted for the three-wire system of feeders and mains with three-wire feeders and two-wire branch circuits.

Figs. 7 and 8 show designs of feeder and main panelboards. Fig. 7 shows a panelboard provided with lugs and fuses for incoming feeder, but without a knife switch to disconnect the feeder from the panelboard. Each of the outgoing mains is provided with both fuses and lugs, but no switches.

Fig. 8 shows a three-wire feeder panelboard for large feeders. The incoming feeder is not provided with either fuses or a knife switch, the fuses being placed at its origin. The outgoing feeders are provided with fuses (as required) but are not provided with knife switches. For large feeders it is always well to provide switches so that the current may be cut off the feeder in case the fuse "blows," as it is very difficult to replace a large fuse with the current on the feeder.

Fig. 9 shows a more recent type of panelboard and one that is coming rapidly into extensive use. It will be noticed that the place ordinarily occupied by the fuses is occupied by a small device (shown in perspective at edge of cut) called a "removable fuse holder." This device, as its name implies, serves to carry the fuse and to make the connection (through the fuse) between the clips on the bus-bar side and those on the branch-circuit side. The contacts are the same as knife-switch contacts. The advantage of this device is that in case a fuse blows, the holder may be entirely removed and replaced by another in which fuses have been placed. The fuses may then be put in the old holder at leisure. Where this device is used it is only necessary to have a stock of spare removable fuse holders, in which fuses have already been placed, on hand, so that when a fuse blows it can be immediately replaced without loss of time and consequent annoyance and without danger of further trouble from short circuits, etc., which are liable to happen in replacing the old style of fuse.

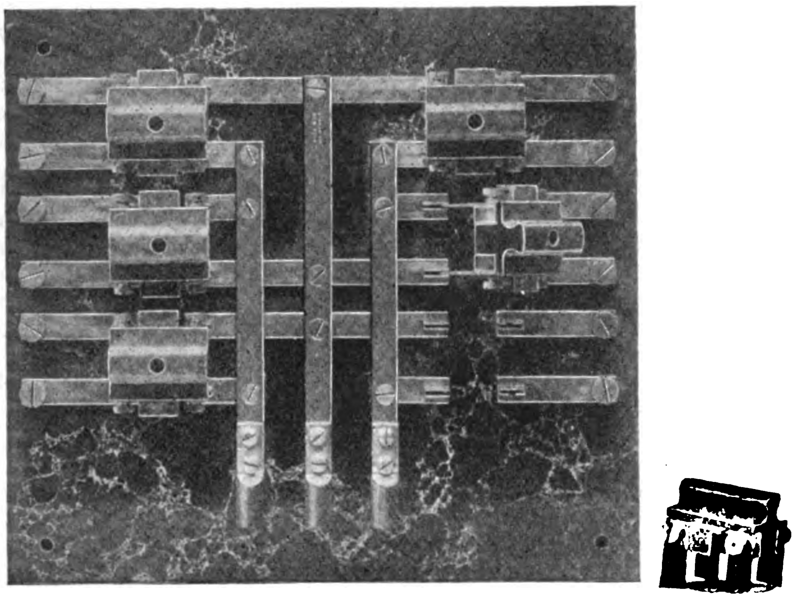


FIG. 9.—BRANCH CIRCUIT PANEL EQUIPPED WITH REMOVABLE FUSE HOLDERS.

Municipal Inspection.

BY A MUNICIPAL INSPECTOR.

This is an article written by an inspector, in which he hopes to present thoughts and experiences which may prove of practical value to those with whom his business brings him in contact.

As a representative of his profession, the electrical inspector need not be introduced to the electrical fraternity at large, for he is well known from architect to wireman. His duty may be summed up in his ability to adapt himself to all sorts of conditions, to meet all emergencies quickly and satisfactorily, and to cultivate a personality that will admit him into a hot, greasy engine room as readily as into a home, and to possess a knowledge of electricity varying from the loss of a three-phase transmission line to the proper amount of an electric light bill for a family of six.

The value of his service is often questioned. Aside from his ability some will agree that the moral effect of his visit is of considerable value. Be that as it may, the rare occurrence of fires due to electrical causes in this age where electricity is so universally used, speaks for the value of his services to the community at large.

His value to the owners and architects in presenting and carrying new ideas and plans from one to the other is not often recognized. He is, as a rule, a veritable mine of valuable information, easily made to give up his treasure, and it is to be regretted that this phase of his work is not more readily appreciated and put to good use. To even the electrical contractor he has a very practical value. Often has the writer suggested plans and changes in construction methods which have saved the contractors considerable sums of money, as well as improved the quality of the work.

In his work the inspector is governed to a large extent by rules and regulations laid down by the Underwriters' Bureau, but these same rules, even if rigidly observed, fall far short of specifying a satisfactory piece of work. The most notable case in this particular are the rules regulating the permissible carrying capacity of wires. No account is taken of "drop in the wire," in the making up of these tables, and as a result a loss of from 10 per cent. to 20 per cent., due to ohmic resistance, is not of rare occurrence in the case of long runs. In one building wired by a responsible company, who look upon the underwriter's rules as infallible, a test made showed a loss of 18½ volts between the service switch and the distribution box farthest away from same, and this on a normal load of 75 per cent. Another building, fed from a plant near by at 112 volts, showed only 90 volts at the lamps under half load. These are, of course, extreme cases, but serve to illustrate how work can conform to the rules and still be deficient. Architects are very careful to specify that the maximum drop shall not exceed 2 per cent., but the writer never knew of but one firm which took the trouble to follow up their specifications in this regard. They trust to the inspector almost implicitly, but in this respect he is powerless to help them.

Often in completed installations it is found that certain lamps will not burn, and investigation shows the cause to be an open circuit, due in many cases to a broken joint. It is the practice of some contractors to pull their tap wires directly off from the wires of the distributing circuits, without the use of knobs to take the strain from the joint. The consequence is that the small copper wire, bent, heated and cooled, often crystallizes and breaks at this vulnerable point, and the defect is not apparent on account of the tape on the joint holding the wires together. The writer has made it a practice to insist on the use of plenty of knobs, and that all joints be left unstrained.

A few construction points might well find a place here. In the case of bracket lights the wires are often run direct to the outlet bushings, twisted together and left. When the fixture is put on, the wires are untwisted, the extra length is pushed back into the partition, where the loosened wires come into contact with each other and with the gas pipe. A much better method of construction is to run the wires down the studding on knobs, and to use a piece of circular loom from the lowest knob through the outlet. This construction also applies to switch loops, and to wiring at cut-out boxes where a number of wires are brought into a comparatively small space.

A suggestion as to the wiring for meters might be of value, not so much to the contractor as to the owner and the electric light company. The rule usually followed is to get the wires outside of the plaster, and some one else will "do the rest." The result is that the wires are run indiscriminately on walls and through partitions in an endeavor to find a suitable place to hang the meter, all of which might have been avoided had the original wireman brought his wires out at a convenient point in the relative position demanded by the meter in use. Where the T. H. or Duncan meter is used, the wires should be brought out in a horizontal row, allowing at least 18 inches head room between the wires and ceiling. This additional space above the meter is necessary to permit the cap to be put on over the meter after it is set.

Now a word about cut-out boxes. When a building is wired the aim of the wireman is to get his wires into the box, and oftentimes no attention is paid to the fact that when the cut-outs are installed these same wires lead, not into, but out of the box. The writer has seen many a cut-out box in which it was necessary to locate every wire with a magneto bell before connecting up, and the loom, bushings and time used in straightening out such a mess cost the contractor a dozen times what it would have cost him to have done an intelligent job in the first place. Oftentimes wiremen are found who do not know the style of cut-out to be used, and who make a guess at the proper method of wiring, the guess to be reasoned out by some one else when the cut-outs are installed. A piece of work was once found where some 40 circuits entered into one box. The wireman had designed his work for Edison plug d. b. blocks, with wires of both polarities on the same sides. When the job was finished a sectional block was used, with all the positive connections on one side and all the negative connections on the other. When the current was turned on not a light would burn, and the contractor was put to considerable expense in altering the work. Even then it was a patched up job, easily liable to cause trouble at any time, whereas an intelligent co-operation would have made a good piece of work possible. Modern practice stands for intelligence and ability, combined with a large amount of common sense, and it is impossible for a contractor to succeed if these requirements are not included in his working capital.

There are some points in the business of the contractor which come to the inspector in ways most forcible. Competition, not of the healthy, hearty, honest type, which one enjoys to meet, but of the dishonest, unscrupulous character, has had its effect upon the electrical wireman's business in a larger measure than in almost any other business. Prices have been cut by unscrupulous contractors actually below the cost of doing the work. The cheapest wire that will pass inspection is used, no matter what is specified, outlets are often not wired when they should have been, and dummy outlets are not unknown. The writer has found in several cases where work was put in after the lathe was on, two outlet bushings nailed to a support, through which were run two pieces of wire a few inches long, tied in a knot at the top end and twisted together at the outlet. Unfortunately for the contractor, the inspector always condemns such work, even if it does not come under the rules.

Specifications sometimes call for a house to be wired for incandescent lights at the gas outlets where shown on plans. And that is all that is done. Wired only, no cut-outs, switches, and oftentimes no provision for any, so that when lights are wanted, it means an extra expense to the householder, who has already paid for a complete piece of work. A case in point was a large flat building, where no cut-outs were installed, nor service switches, and where the service wires were left concealed in the walls instead of being brought outside where service connection was possible. It meant a saving on this item alone of the cost of drilling eighteen holes through a twelve-inch brick wall, and if the inspector in the case had not done his full duty, the owner would have been defrauded of several hundred dollars. And to crown all, the architect had accepted the work as completed and had issued an order on the owner for the amount of the contract.

And this brings us to another character who enters into every contract, and that is—the architect. The writer's acquaintance among this fraternity is large, and there is no nobler nor more respected calling in the world today, and it is filled with men who are worthy of it, but one thing they lack almost universally. A comprehensive ignorance of electricity and its requirements is most evident among them. This term is used advisedly, for I number among many warm friends architects who "know it all" and who will not learn. They are easily hoodwinked, and made to believe almost anything by sales agents and contractors. Their specifications are loosely drawn, as a rule, and a large percentage do not understand themselves what they have specified, except for their bell and speaking tube work. I have looked over specifications many times, where several pages were given up to bells, tubes, telephones and burglar alarm work, and little more than the simple sentence "Wire for electric lights at gas outlets where shown on plans" disposed of the lighting installation. Not a word about the type of cut-out, nor switches for center lights, nor three and four-point switches for controlling the hall lights, nor any means whatever for utilizing the most valuable feature of electric lighting, its power to be controlled from a distance. The completed result of such specifications can well be imagined. Speed the day when such a condition of affairs will be impossible.

A word should be said in behalf of the company which furnishes the current, for it is upon them that the burden of keeping an installation in working order always falls. Many an owner has allowed an irresponsible electrician, some "bright young fellow," to wire his house because he was the lowest bidder, and then has condemned the electric light company because his electric light service was not as satisfactory as that of his neighbor, who paid twice as much to have his work put in right.

It is necessary in these days that current be metered, and often do we find meter loops in halls and other conspicuous places, where the presence of an unsightly meter is a positive disfigurement to the home. Many a housewife has refused to use electric current for this reason, and revenue is thus lost to the company.

This article would not be complete without a word regarding fixtures and their design. A 16-c. p. lamp, ten feet from the floor, should properly illuminate 100 square feet. But it must not be hid under a bushel, nor turned up toward the ceiling with an opalescent reflector underneath. Nor should the translucent pendant shades, just now so very popular, be expected not to diminish the brilliancy of the light in tempering or softening the same. The fixture men may be artists in their line, and their product may be artistic, but they are not practical nor can they be considered as having attained anywhere near to perfection when they sacrifice utility to appearance at such an enormous cost. The popularity of the incandescent gas lamp is due to the fact that it fulfills its mission, that is, it gives light, and lots of it. It is a harsh, cold light, too, but it illuminates, and that is more than the best incandescent lamp can do operating under the handicap of the artistic fixture creation of the present day. The writer knew a man who paid $30 per month for the privilege of having such fixtures in his home, and who had to light a student lamp whenever he read his evening paper.

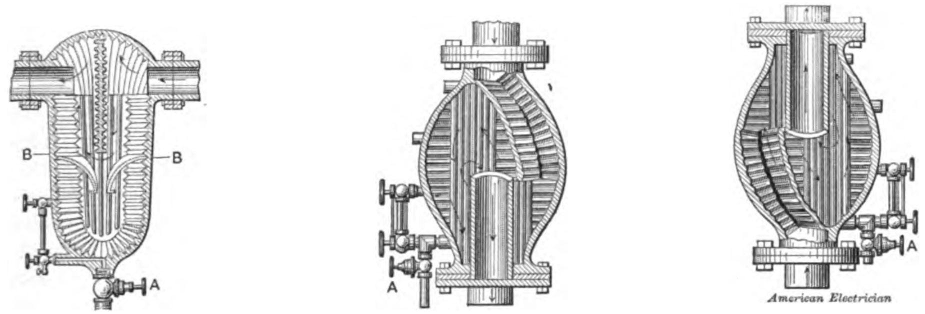
In closing, a word to the consumer of electric current seems most appropriate. When you wire your house put a switch on every outlet possible, use as elaborate a system of control as your pocketbook will allow, for the saving in your bills from this source alone will pay a large interest on the additional investment. Use lamps of small candle power. It is better to put four 8-c. p. lamps on a fixture, and burn them all, than to put on four of 16 c. p. and to burn only two. The distribution is much better, as well as the appearance, and the cost is the same. The illuminating power of two 8-c. p. is considerably greater than that of one 16-c. p. lamp, the benefits thus resulting from the use of a large number of small light units being considerable.

This article has touched upon a large number of points, but the inspector must meet them all, and many more besides. The slander and abuse heaped upon him as to incompetence and unfairness, I wish to refute and to declare as false and unfair, and to bespeak for him from the electrical fraternity at large the same courtesy and fairness which is shown to those who are not so unfortunate as to be municipal inspectors.

OIL AND WATER SEPARATORS.

Last month this space was almost entirely given up to grease extractors of the centrifugal type. This month, some of the baffle-plate appliances will be described; also a few of the tubular concerns. But the separators are so combined in their action and construction that it is almost impossible to select one which represents purely a single type. That means that each separator is constructed to combine the advantages of two or more types. Fig. 1, which shows the Austin separator, is an example. Not only is this separator of the inverted syphon type, but it is strictly a baffle plate also. This form is perhaps the most common. This separator is made by the Austin Separator Company, Detroit, Mich. In action the combined steam and water impinge upon the corrugated surface of the separator, the oil adheres to the corrugated surfaces and finds its way to the chamber in the bottom of the device, from which it may be blown off at will by means of the pipe arranged for that purpose. It is obvious that this appliance may be used for water as well as for oil separation.

Another well-known form of separator, which embodies these types, is shown by Fig. 2. This is the Hine eliminator, by James L. Robertson & Sons, New York. The three sectional cuts comprising Fig. 2, show the construction of the appliance for three distinct kinds of work. The interior surfaces are deeply corrugated throughout, which breaks up the passage of steam and water currents through the device. In the horizontal style a corrugated vertical diaphragm interposes between the inlet and outlet side. By force of the incoming current the steam is driven against this diaphragm, and by expansive impingement of the transverse corrugated surfaces the initial separation takes place before the turning of the steam into the outlet side. At proper distances below this vertical diaphragm are two converging discs, between which the particles eliminated pass into the chamber below, out of and away from the steam current, and are discharged, while the clean dry steam passes on under the diaphragm, being deflected by an inward extending pipe at the point of outlet.



HORIZONTAL.

VERTICAL WHERE COURSE OF STEAM IS DOWNWARD

VERTICAL WHERE COURSE OF STEAM IS UPWARD.

FIG. 2.—HINE ELIMINATOR.

The other two sections show varieties for handling steam in vertical pipes, one being for steam ascending, the other for use when the current is descending the pipe. At the side, on one end, a corrugated deflecting partition extends half the length of the body, forming the inlet. At the opposite end a vertical pipe cast with a flange and standing out from the body, forms the outlet. The steam, in passing through the deflecting partition, obtains centrifugal action, and by expansive contact with the inner corrugated surfaces is broken up, and the water, oil, grease, or other particles, eliminated, readily flows down the vertical corrugations and out, while the steam, diverted from its direct current, passes through the vertical pipe to point of delivery. The action of steam is essentially the same in both these forms, although the construction is necessarily different in order to meet the varied conditions imposed.

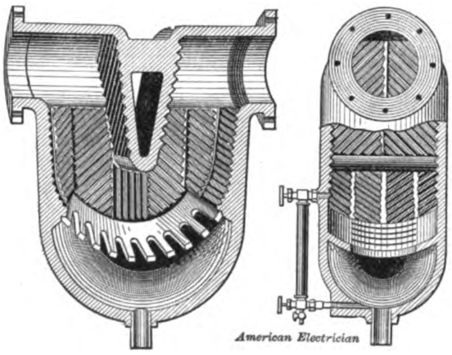
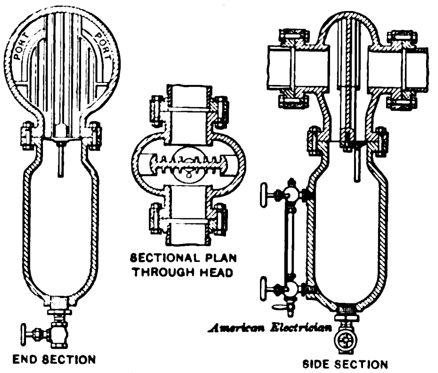


FIG. 1.—AUSTIN SEPARATOR.

Fig. 3 shows a widely-known form of separator, the Cochran, made by the Harrison Safety Boiler Works, Philadelphia, Pa. This separator is made in a number of forms, notably the horizontal standard, the horizontal high-pressure and the vertical standard and low-pressure types. There is also the horizontal receiver form for steam service under any pressure up to 200 pounds per square inch.



END SECTION

SECTIONAL PLAN THROUGH HEAD

SIDE SECTION

FIG. 3.—COCHRAN SEPARATOR.

The "Standard" types, both horizontal and vertical, are designed for oil separation and for use in steam mains of any pressure up to 125 pounds. The high-pressure types work up to 200 pounds and are used in both steam service and in compressed air. These are also made for higher pressures, but the construction is the same except that the strength is greater. The low-pressure forms are more square than the high-pressure ones, in which there is an almost entire absence of angles, circular and spherical construction being used entirely, and great strength secured thereby.

The design of these separators is such that the steam passes to the right and left of the baffle plate, never over or under it, thereby giving the oil or water every opportunity to pass out of the steam without being caught up again, and carried along after it has once been thrown out. There is a single baffle plate in these separators of such size and so located that it is in just the right place. This concern claims that one plate is as good as a dozen if it is just big enough, therefore they only use one plate, but take care to put it where it will do the most good. The makers claim that if the water is allowed to fall from the plate there must be no current of steam to disturb the water when thus in motion. They also claim that it will not do to carry the steam up over the plate lest some of the separated water be carried up therewith. Thus they make the openings on either side of the baffle plate. In doing this it is necessary to provide against the carrying off of the water on the outlet side of the baffle plate. There is danger of steam picking up the water just as it and the oil might be leaving the baffle plate. To prevent this, they simply close the space between the baffle and the head proper, on the outlet side. Then, by arranging to drain the chamber thus formed, there will never be any trouble from the causes above stated, and the principle of a good separator is secured at once.

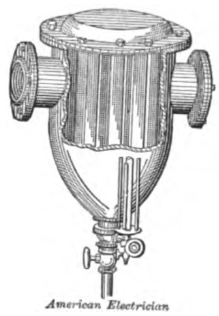


FIG. 4.—ACTON WATER SEPARATOR OR GREASE EXTRACTOR.

As stated, the vertical form is the equivalent of the horizontal type, with the necessary changes to take care of the different movements of the steam currents. It is an essential point of these separators that the well is entirely below the influence of the steam currents, and these currents not being discharged into the well, the latter may become entirely filled with water or oil without danger that any portion of the contents in that receptacle will be taken up and carried along again. It is claimed that this separator will take out 90 per cent. of the entrained moisture when only 1 per cent. is present, and that it will take out 99 per cent. when over 60 per cent. is present. This is efficiency indeed. The Cochran separator never need be cleaned. The plate is of such size and shape that the oil drains off of it, and none stays to become hardened or to clog up the surfaces thereof.

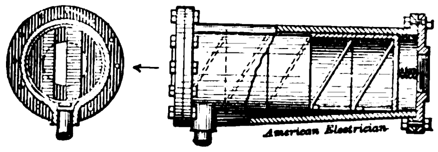


FIG. 5.—THE UTILITY OIL SEPARATOR.

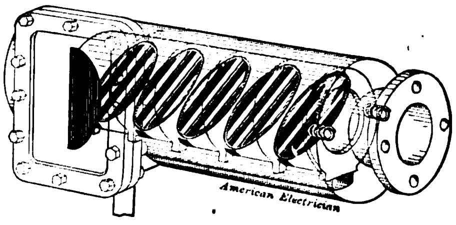


FIG. 6.—EFFICIENT STEAM SEPARATOR.

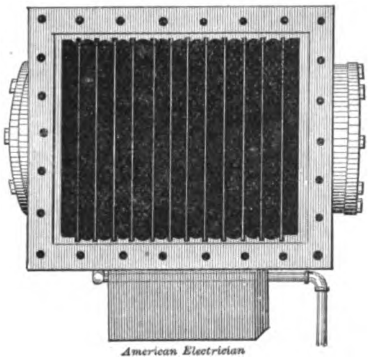


FIG. 7.—PEERLESS GREASE EXTRACTOR.

Another type of the side-outlet baffle-plate extractor is shown by Fig. 4. This is known as the Acton steam and water separator, and it is made by a company which does not put its name upon its catalog of steam specialties, but whose address is 118 John Street, Brooklyn, N. Y.

It is claimed that the section of this extractor has 25 per cent. more area than that of the steam pipe. The baffle plates, as are shown, are suspended from the top of the device and extend downward into the well. This separator has the advantage of great simplicity, as the entire working parts can be taken out by simply removing the top or cover of the containing casting.

The Utility Steam Specialty Company has placed on the market a pair of separators, one of which is for water, the other for oil. Fig. 5 shows the oil separator, Fig. 6 the one made for water. This company is one of the few concerns making different separators for the two kinds of work, the same appliance usually being designed to do both. The oil separator, as shown by Fig. 5, contains several plates placed obliquely, in such a manner as to still leave a free passage for the steam, although intercepting and draining off the water. It will be seen in the engraving that there is a straight passage through the separator, as shown by the end view at the left of the picture.

Fig. 6 shows "The Efficient Steam Separator" by the same company. In this device there is a series of inclined "grid-iron" baffle plates which also allow a free passage of steam while intercepting the water. This appliance is designed for the highest modern steam pressures, and is readily accessible for overhauling and repair, as the baffle plates can at any time be removed without breaking the steam line.

There are a number of types of baffle-plate separators on the market which do not use the conventional baffle plate. They are "straight way" appliances, yet they must be called "baffle plate" as well. Fig. 7 shows a separator of this type. It is known as the Peerless, and is made by Hussey, McCann & Co., New York City.

As shown by the engraving, this device contains a number of vertical wire screens which intercept the oil and water, conducting the same to the lower portion of the containing vessel, where it is collected and carried into a receptacle for holding it until drawn off. The side plate is removed, as shown in the engraving, showing how the screens are put in and removed. The total opening in the screens is largely in excess of the pipe opening, so that there is no back pressure caused by a contraction of the pipe area. These are made either with side or top opening, as desired, accordingly as there is space at the side or on top of the pipe for the withdrawal of the screens when that operation is necessary. There are other forms of direct baffle-plate extractors, and one, an excellent type of the direct-passage baffle-plate form of extractor and separator is shown by Fig. 12, which shows a Bundy Separator, made by the A. A. Griffing Iron Company, New York. The engravings show the arrangement of the baffle plates, and also permit a detail view of a set of baffle plates. In describing the action of this separator, it may be stated that in destroying the momentum of the suspended particles of water or oil, the course of the steam should remain the same for two reasons: First, because any diversion from its natural course must result in the impairment of its elasticity and consequently a partial destruction of its mechanical usefulness. Second, because the steam, being deflected from its course, starts off in the new direction with its full expansive force; and should this change bring it into contact with the water precipitated into a receiver by gravity or centrifugal force, violent ebullition will take place, resulting in the re-saturation of the steam.

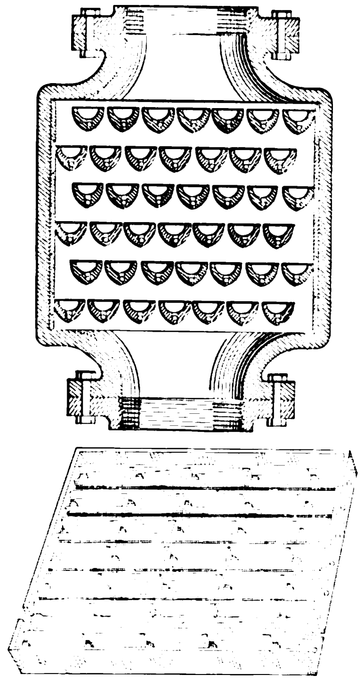


FIG. 8.—BUNDY OIL SEPARATOR.

Letters on Practical Subjects

Pioneer Interior Wiring.

To the Editor of American Electrician:

I have recently come across an interesting specimen of interior wiring, recently removed from a building in New York City, and dating back fifteen years or more. When the pioneer Edison station in Pearl Street was under construction, the various subscribers for light were wired up on this system, which furnishes a strong contrast to present methods. The wire used was the ordinary kind of cotton braided and waxed wire—so-called office wire—ranging in size from No. 16 to No. 20 B. & S. These wires were held to the walls and ceilings by wooden strips of semi-circular cross-section, each with a single longitudinal groove. All this wiring was two wire, and the two wooden strips protecting and holding their respective wires were held in position by properly spaced bent iron straps fastened with a centrally placed screw. The cut-out devices of those days were wood, and it is interesting to note that the present Edison type of cut-out follows the same general lines. The main line cut-outs were also made of wood with single-pole screw fuse-plugs.

Many of the other elements embodied in these early Edison installations seem to have been followed even to the present time. During the early development of electric lighting, the completeness of detail of this system was notable. It is not only a fact that such installations worked then, but it is not so very long ago that the writer remembers seeing wiring of this kind still in service on the Edison mains in the lower districts of this city. Those who are so fearful of our present methods might find much food for thought in these early installations. Chas. L. Burton.

New York.

Electrical Catechism

382. Give an example to illustrate this point.

Assume the line pressure to be 100 volts, the armature resistance to be 1 ohm and the c. e. m. f. to be 90 volts: the current is 100 minus 90 divided by 1, or 10 amperes; the power delivered by the motor is 10 multiplied by 90, or 900 watts; while the power taken by the motor is 10 multiplied by 100, or 1,000 watts. Now suppose the c. e. m. f. drops to 60 volts: the current is 100 minus 60 divided by 1, or 40 amperes; the power delivered is 40 multiplied by 60, or 2,400 watts. Suppose the c. e. m. f. is 50 volts: the current is 50 amperes, and the power delivered is 2,500 watts. Suppose the c. e. m. f. is 20 volts: the current is 80 amperes, and the power delivered is 1,600 watts. It is thus seen that the power increases until the c. e. m. f. equals half the line e. m. f., after which the power becomes less, although the current continues to increase. (As a general rule the safe current carrying capacity of the armature will be passed before the c. e. m. f. drops to 50 per cent. of the line voltage.)

383. What is meant by the efficiency of a motor?

The efficiency of any machine is the ratio of the power delivered to that received. The total power given out by a direct current motor is the product of the armature current by the c. e. m. f. The net power delivered is something less than this by an amount equal to the heat loss in the armature core plus the friction at the brushes, bearings and against the air. The total power received by the motor includes sum of the electrical energies given to the armature and to the field. We may distinguish between the electrical and the commercial efficiency of a motor.

384. What is meant by the electrical efficiency of a motor?

The electrical efficiency of a motor is the ratio of the product of armature current by c. e. m. f. to the total electrical energy supplied to the motor. Neglecting the small amount taken by the field we may say that the electrical efficiency is the ratio of the energies in the armature, that is the product of armature current by total voltage across the armature divided by the product of the armature current by the c. e. m. f. Since the current is the same, in numerator and denominator, we may cancel it and say that the electrical efficiency is the total voltage divided by the c. e. m. f. (The above refers only to direct current motors, for in A. C. motors the c. e. m. f. may be smaller or larger than the line voltage, and the product must be multiplied by a factor depending upon the difference of phase between current and pressure. (See also No. 377.)

385. What is meant by the commercial efficiency of a motor?

The commercial efficiency is the ratio of the power delivered from the pulley to the total electrical energy received.

386. How can the c. e. m. f. be measured?

It cannot be measured directly. It can be calculated by taking the difference between the total pressure at the terminals of the armature and the product of armature current by the resistance of the armature.

387. Show how the efficiency of the motor is affected by changes of c. e. m. f. in the above case (No. 382).

When the c. e. m. f. is 90, the energy taken by the motor is the product of current by volts, 10 times 100, or 1,000 watts; the power delivered is 900 watts, making the efficiency of the motor to be 900 divided by 1,000, or 90 per cent. When the c. e. m. f. is 20, the power taken is 80 times 100, or 8,000 watts, while the power delivered is 1,600 watts, and the efficiency is 20 per cent. The efficiency is thus seen to be equal to the c. e. m. f. divided by the line e. m. f.

388. How does the c. e. m. f. affect the starting of a motor?

When a motor is standing still, there is no c. e. m. f. due to armature rotation, and the current taken at first is governed principally by the resistance of the circuit. If the motor is series wound, there is a transient c. e. m. f. due to self-induction for a few seconds during the rapid building up of the magnetic field. If the motor is shunt wound, self-induction delays the current through the field coil, but that through the armature is not impeded much from such cause. As soon as the armature begins to rotate, the motor e. m. f. begins to develop and the resistance may be cut out gradually from the starting box as the armature comes up to speed. Thus counter electromotive force gradually replaces ohmic drop in limiting the current as the motor starts.

389. What governs the current taken when the motor is running at full speed?

At a given load and speed, the current is governed by the c. e. m. f. and the resistance of the armature circuit (neglecting the small current through the field), and the pull on the belt is just enough to turn the shaft at the right speed. If an additional load is put on, the pull on the armature for an instant is not large enough, and it begins to slow down; this reduces the c. e. m. f., which allows greater current to pass and increase the pull on the armature and so bring the armature up toward its original speed. If the voltage on the line remains constant and if the magnetic field of the motor is not changed, the armature will run somewhat slower as the load increases.

390. Does the resistance of the armature have much to do with the amount the speed slows down?

The less the resistance of the armature, the more nearly the c. e. m. f. equals the line voltage, and the less reduction of c. e. m. f. necessary to allow the greater current to pass. Hence the speed of the motor will be more constant for varying loads as the resistance of the armature is less.

391. How does armature resistance affect the efficiency of a motor?

The efficiency is higher as the armature resistance is lower. The voltage of the line is balanced by the sum of the c. e. m. f. and the ohmic drop through the armature. The ohmic drop equals the product of current by resistance. Hence for a given current, the less the resistance the less will be the ohmic drop and the greater will be the voltage left to balance the c. e. m. f. As was seen in No. 380, the efficiency is greater as the c. e. m. f. is greater; hence the less the resistance of the armature, the greater will be the efficiency of the motor.

392. Can the resistance of the armature be changed?

Only by rewinding it. It should be remembered, however, that part of the resistance of the armature circuit is at the contact between the brushes and commutator. Therefore a motor with dirty or uneven commutator, loose brushes and poor connections will not run at so uniform speed as the same one when put into first-class running order. Any perceptible heat around the brushes or holders should therefore be investigated.

393. What regulates the speed of a motor?

The speed of a motor is governed by the resistance of its armature circuit and by its c. e. m. f. Enough current must pass through the armature (with a given magnetic field) to make the torque or pull equal to the load. This current multiplied by the resistance of the armature circuit gives a certain ohmic drop. The c. e. m. f. must equal the difference between this and the line voltage. With a given magnetic field and armature, the only variable element in the c. e. m. f. (see No. 375) is the speed. This therefore must be such as to bring the c. e. m. f. to such a value that the difference between it and the line voltage will just send sufficient current through the armature to give the necessary torque.

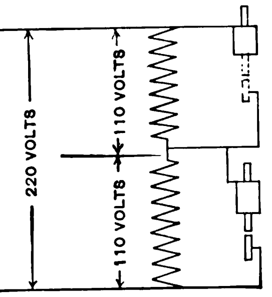
394. How can the speed of a motor be increased with a given load?

The speed of a motor on a constant potential circuit can be increased either by reducing the resistance in the armature circuit or by weakening the magnetic field—that is, by reducing the effective number of magnetic lines of force through the armature.

Queries and Answers

It is desired to use alternating arc lamps commonly used on 100 to 110-volt circuits on 220-volt or 440-volt a. c. circuits, without converters or transformers, if possible. What is the best way of doing this? S. W. F.

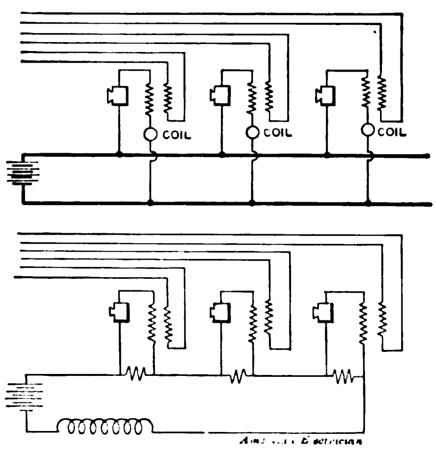
It is a difficult matter to make 110-volt arc lamps made for parallel operation burn in series with each other on 220 or 440-volt circuits without auto-transformers, compensators or economy coils in multiple with them. This is owing to the fact that their regulation is accomplished solely by series coils so that the lamps tend to rob each other. Of course a 110-volt lamp can be burned alone on a 220-volt circuit by inserting in series with it a choking coil. Such a choking coil can easily be made of an old 10-light transformer, rewound with about one-fourth the number of turns which it has in its secondary to give 50 volts. This method is unsatisfactory as it introduces bad lagging currents in the system and interferes with voltage regulation. A great deal better way is to work two 110-volt lamps on a 220-volt circuit by means of a single-winding transformer, a simple device which goes by various names, being called by the Westinghouse Company an auto-transformer and by the General Electric Company a compensator. This consists of a transformer, the primary and secondary of which are wound on the same core in series with each other. The general arrangement of the circuits is shown in the diagram given above. In this case the two windings in series with each other have exactly the same cross section and number of turns. Their tendency is to keep the middle point, to which they are both connected, exactly at a mid-potential between the two outside terminals. For instance, if the lower lamp takes more current than the upper one, half of this excess current comes through the upper coil and by the transformer action generates the other half in the lower coil. The machine is practically a balancer, tending to balance the voltages on the two sides of what might be called its neutral. With such a transformer as this 110-volt lamps can be used with perfect satisfaction. One can readily be made from a 110-volt transformer by removing the primary and replacing it with an exact duplicate of the secondary winding. This new primary should then be connected in series with the secondary.



THE CONNECTIONS OF A SINGLE-WINDING TRANSFORMER FOR RUNNING TWO CONSTANT POTENTIAL ALTERNATING ARC LAMPS IN SERIES WITH EACH OTHER.

Would it be possible in a telephone exchange of 50 subscribers to have the local battery at central by running two common-battery wires and including a choke coil or some other similar device in the local battery circuit of each 'phone as shown in the sketch sent herewith? W. J. E.

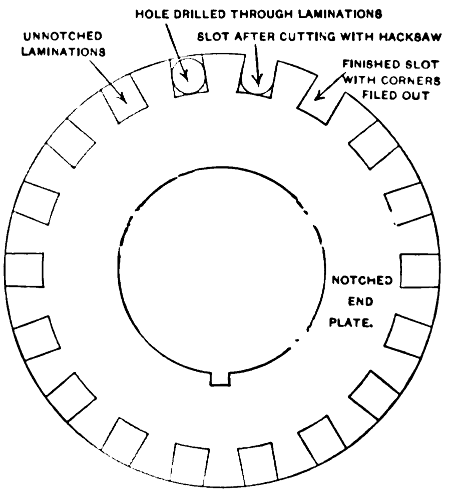
Such an arrangement of a common battery would be possible, but a choke coil should not be included in the branch to each subscriber, as such a coil tends to kill out the very fluctuations of the current that are desired for telephoning purposes. Presumably the purpose of your choke coil was to prevent cross-talk through the battery mains, but this can only be prevented by making these mains of such low resistance that the current through them will not cause a drop of more than five or ten per cent between the battery and the instruments. If the drop is greater than this the fluctuating current when one instrument is talking will cause a fluctuating drop, which will in turn cause fluctuations of the pressure on any other microphone that may be in use, setting up cross-talk. The problem is, as you will readily see, the same as that of incandescent light wiring only at a much lower potential, and on this account such distribution cannot be carried long distances. A common battery can be used in this way in one set of offices, or even in one large building, if the mains are of sufficient cross section, but if the lines are carried any considerable distance the drop becomes so great that the fluctuations set up by one instrument affect the pressure impressed upon the other microphones near it, setting up fluctuations in them and causing prohibitive cross-talk. A better method that might prove practicable would be to connect all the microphones in series just as arc lamps are connected in an arc circuit, putting a non-inductive resistance of 1 or 2 ohms across the terminals of each microphone and induction coil primary so that each instrument could vary its current without affecting materially that in the main line. The latter could be kept more steady by the insertion of one good, big choking coil. The arrangement is shown in the accompanying diagram. This method might prove practicable, but has not, so far as the writer knows, been tried on a large scale.



DIAGRAMS OF TWO SCHEMES OF COMMON BATTERY WORKING FOR TELEPHONE EXCHANGES. THE UPPER ONE IS THAT OF THE QUERY, THE LOWER ONE THAT OF THE ANSWER.

How can I obtain the slotted armature discs for the small motors, the designs of which have been given in the American Electrician? A. R.

These discs cannot be bought in the market, as the punchings and dies for them have not been made. They can, however, be readily made up from round discs. You can buy the latter of the right diameter to cover the outside of the teeth and with the proper hole for the shaft from makers of discs, such as Thomas Smith & Co., 14 Cypress Street, Worcester, Mass. If you want to make them yourself you can cut them out of sheet iron nearly round with ordinary shears. You can then clamp them in a vice and drill the shaft hole through them. They can then be mounted on a shaft and turned into true round discs. To notch these discs you must first prepare one end plate of thicker metal, about ⅛ inch thick, and preferably of cast iron; space off your teeth and notches on this plate and file the notches into it. You can then mount this end plate on the shaft with your laminations and drill holes through the latter, one for each slot, guided by the notches already made in the end plate. This hole should be the full width to which it is intended to finish the slot and the lower side of the drill should run against the bottom of the slot. The two sides of the slot can then be cut out with a hack saw from the surface down to the hole. This will leave the slot complete except for the two bottom corners which will have to be filed out. If the armature is so long that you cannot drill through all the discs accurately you can drill them in two or three separate batches, using the same end plate as a guide for all the batches.


HOLE DRILLED THROUGH LAMINATIONS
UNNOTCHED LAMINATIONS
SLOT AFTER CUTTING WITH HACKSAW
FINISHED SLOT WITH CORNERS FILED OUT
NOTCHED END PLATE.

A METHOD OF MAKING SLOTTED ARMATURES WITHOUT A PUNCHING MACHINE.

COMPOSITE-WOUND POLYPHASE ALTERNATORS.

In the ordinary composite-wound single-phase generator the series or auxiliary coils of the field windings, which build up the excitation as the load increases, are supplied through a rectifying commutator cut into one lead from the armature winding to one of the collector rings. With two-phase machines an arrangement as simple as this would only take into account the load on one phase. With three-phase machines the effect would be proportional to the outgoing current in one leg of the circuit. It is possible, of course, to use two or three separate rectifiers and sets of auxiliary field coils, one for each phase, but this arrangement is more complicated than the case necessitates.

An ingenious device for making all phases act on one set of series coils through one rectifying commutator as used by the Westinghouse Electric & Manufacturing Company, is described and shown in the diagrams below. The arrangement makes use of a device also utilized in single-phase alternators made by the same company, i. e., a series transformer, mounted on the spokes of the armature and hence rotating therewith. By means of this series transformer the voltage delivered to the rectifying commutator and the fields is much less than that generated by the machine. Thus, these parts need only be insulated for some 50 volts instead of 2000, as would be the case were there no series transformer used.

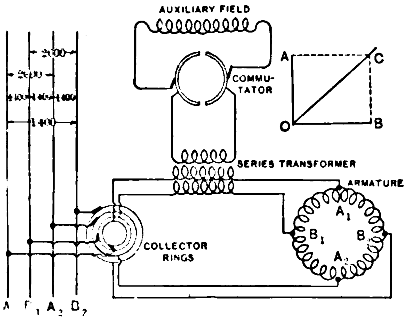


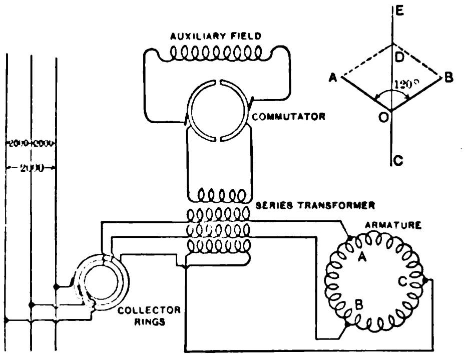
FIG. 1.—THE CONNECTIONS BETWEEN A TWO-PHASE ARMATURE AND A SINGLE-PHASE RECTIFIED AND COMPOSITE FIELD WINDING.

In polyphase machines this transformer, instead of having one primary, has two or three, according to whether the machine generates either two or three phases. The general arrangement of the circuits in the two cases is shown in the accompanying diagrams. In Fig. 1 the two-phase case is represented. As may be seen, the armature of this machine is of the closed-coil single-winding type, all the armature conductors being connected with each other to form a closed circuit which resembles to a certain extent the ordinary drum-winding of a multipolar direct-current machine. This winding is tapped out at two points per pole just as is the continuous winding of a two-phase rotary converter, these taps running to collector rings through which the currents are delivered to the outside circuits. On account of this connection of both phases to one winding there is a definite electromotive force set up between the conductors of phase A and those of phase B, this electromotive force being shown by the figures given in the diagram.

The whole arrangement is adapted for two-phase work by fitting the series transformer for the auxiliary field excitation with two primaries connected respectively in one leg of each of the two phases; thus the transformer is excited by two currents normally ¼ period out of phase with each other. The result upon the secondary is a combination of the effects of the two primary currents, the electro-motive force delivered by the secondary being intermediate in phase between those e. m. fs. which would be separately set up by the two primaries. This combination effect is shown in the small diagram in the upper right-hand corner of the illustration. If O A is the effect set up in the secondary of the series transformer by the primary current of phase A, and O B is the effect set up by the primary current of phase B, O C represents in magnitude and phase relation the resultant effect upon the secondary. It is readily seen that this resultant is not equal to the arithmetical sum of the two components since to a certain extent they work at cross purposes. However, if either one of its increases the resultant effect increases, although not in exact proportion. If the load remains balanced, the two components remaining equal to each other, the resultant O C varies in exact proportion to any changes in the components. If the load becomes unbalanced, one phase getting more work than the other, the resultant swings around more nearly into phase with the larger load; thus if O B becomes greater, O A remaining the same, O C swings around, becoming more nearly horizontal. This requires a readjustment of the position of the brushes on the commutator to set them properly for minimum sparking, an adjustment exactly similar to that required when the power factor of the load changes. Theoretically the two primary windings on the one series transformer tend to exert an influence upon each other, such as to throw the currents of the machine out of the phase relation set up by the armature, but owing to the fact that but a very slight amount of the total drop of the circuit is in this transformer the effect is practically a negligible one.

Fig. 2 shows the arrangement adopted for three-phase machines. In this case also the armature conductors are of the closed-coil or delta-connected type, but are tapped at three points per pair or poles to the three collector rings. All three connections between the armature coils and the collector rings run through primary circuits of the series transformer within the armature, these three primaries each giving their own effect upon the secondary. As is well known, the resultant of three equal alternating electromotive forces 120° apart is zero, so that some special arrangement must be adopted to make these electromotive forces act with instead of against each other. The arrangement is a reversal of the connections of one of the primaries of the series transformer. This is shown in the case of the lowest primary indicated in the diagram. The combination of the effects of the three primaries is again indicated in the small vector diagram in the upper right-hand corner. Here O A is the effect of one primary, O B that of another 1/3 of a period displaced from the former in phase, and O C that which the third would exert were it not reversed, but the reversal brings the effect of this third coil into the phase relation O D, so that the three are only 60° apart. The combination of O A and O B is equal to O C, which combined again with O D gives a resultant effect, O E.

In this case, as in the other, the effect upon the series field does not remain exactly proportional to the load unless the latter is balanced; in fact, an increased current through the one leg represented by O D, affects the series field as much as an equal increase in each of the other legs put together. Practically, however, any increase of the load—distributed as it must be in two legs at least—increases the field excitation so that proper regulation is secured.



American Electrician

FIG. 2.—THE CONNECTIONS BETWEEN A THREE-PHASE COMMUTATOR AND A SINGLE-PHASE RECTIFIER AND COMPOSITE FIELD WINDING.

A MANUFACTORY OF CLAY AND PORCELAIN INSULATING APPLIANCES.

In one direction electrical engineers and users of electrical energy are studying how to produce or find a material or medium that will conduct the current with least resistance and loss, and in another direction are seeking a material void of conducting properties, on which to mount or support the conductors in order to insulate them from loss of current and from dangerous contact. Nature seems to have provided a substance suitable for this use in the clays and silicates, and although these are very common elements only certain grades are found to be of a proper character to produce the best goods for this purpose. There are certain counties in Ohio in which the surface for a considerable depth consists of numerous argillaceous deposits or drift clays known as fire-clay and shale, which are supposed to have been of Northern origin, and which were formed by glacial action and deposited as sediment from lakes and pools following the retreat of the ice floe.

These deposits have become an important element of wealth to the State for they supply the material from which nearly all the stoneware of the country is manufactured, as well as material for fire-brick, paving brick, sewer pipe, underground electrical conduits and more recently material for interior house wiring specialties, such as tubes, knobs, cleats, switch bases, etc. Summit County is especially noted for these deposits and all about Akron, the county seat, are found extensive manufacturers of these wares, and among them the Akron Insulator and Marble Company is of special interest, as the entire energies of the works are now directed to the manufacture of interior wiring specialties and such special designs as may be ordered, the company making a specialty of new designs. The products, however, are not all produced from native clay but embrace also porcelain goods which are made from imported materials.

The material for the clay goods is purchased from the mine owners all ready tempered or mixed and prepared, and is of a gray or blueish tint, which when baked is nearly white and is glazed in dark or light colors as may be required. For all purposes the material is forced through dies in screw presses in the form of tubes or rods, which are afterward cut up into suitable lengths, the tubes being made up to two inches in diameter and twenty-four inches in length. For making short tubes up to four or five inches in length and for knobs and cleats the material is first formed in rods of various diameters. These rods having been allowed to dry for a certain period are cut up into suitable lengths, and the short tubes are formed by clamping the section in a two-part metal die, which is closed by foot power and which is provided with a small hole in each end. A rapidly revolving mandrel is then forced through the mass, leaving a smooth uniform bore, after which the die is opened, and the form removed and placed upon a grooved wooden tray, after which the webs and surplus material are carefully scraped off. For this purpose there are five machines in the works each operated by an attendant who is able to form 6000 a day.

The trimming is mostly done by female help, who also do the sorting and packing into the seggers preparatory to the baking process. The cleats are also formed from cylindrical bars pressed into shape and stamped by a die operated by a screw. There are three of these machines and the attendant is able to form 7000 per day. The porcelain products are mostly pressed dry, the powder being placed in the die when they are formed under heavy pressure produced by a screw which is operated by hand, the long arms of which terminate in heavy iron balls which from the momentum give an enormous pressure. There are a number of these presses as well as other finishing tools. The knobs after being formed have the grooves turned in by placing them on the spindle of a lathe.

After the various shapes are made they are placed on racks in wooden trays where they are left to dry, suitable temperature being provided by steam pipes. When sufficiently dry they are packed in seggers which are shallow pans made from fire-clay, and which are manufactured in another department. These with their contents are now piled in tiers in the kilns, of which there are four of the ordinary dome-shape down-draft type. The baking process occupies two days and two nights, but it requires about a week to allow for cooling off and recharging.

The company makes its own dies, and, as said above, makes a specialty of new and odd designs to suit customers. The company is enjoying a very liberal patronage, having among its customers many of the most prominent electrical manufacturers of the country. At the time of the writer's visit it was filling an order for a million tubes from one customer, and another order for 470,000 pieces of special design.

The works are located on the outskirts of the city, and are served by sidings from the neighboring steam railway, so that coal and material are delivered directly to the works and the shipments are made from a platform beside the packing room. The stock room is well supplied with bins and cases for keeping the different patterns by themselves and a large quantity is constantly carried in stock, so that most orders can be promptly filled. The works of the Akron Insulator & Marble Company employ from fifty-five to sixty hands, and are operated under the direction of J. P. Loomis, President and Treasurer; W. H. Motz, Vice-President; J. R. Hemphill, Secretary and manager of the works, to whom the writer is indebted for courtesies shown.

THE INTERNATIONAL CORRESPONDENCE SCHOOLS AND THEIR ELECTRICAL COURSES.

There has been developed in this country during the last ten years an entirely novel means of education, departing from all previous methods in that it is carried on by means of correspondence through the mails. The plan has proven surprisingly popular, as it enables the industrial classes to obtain by study at home, at odd times, an education in practical subjects without devoting their whole time for several years and a large sum of money to courses in the regular engineering schools.

The growth of the International Correspondence Schools of Scranton, Pa., which are typical of this method of education, has been so rapid as to be phenomenal. They developed originally from a demand made by the miners of Pennsylvania for education to help them pass the mine law examinations. Mr. T. J. Foster, manager of "The Colliery Engineer and Metal Miner," Scranton, prepared, in 1891, a course of study in mining to meet this demand, and from this small beginning the schools have grown until now there are some 66 separate courses conducted by a corps of 120 instructors, with 130,000 students enrolled.

The system of instruction is based fundamentally on "instruction papers," which are pamphlets of from 30 to 150 pages, convenient for the pocket and hence for study at any available time. These papers are frequently revised to make them clearer on points which correspondence with students shows are most difficult, are made as simple in style as the subject will permit and are freely illustrated. Each course is made up of from one to sixty instruction papers and accompanying "question papers" containing test questions. These papers become the property of the student, who, however, agrees to reserve them solely for his own use.

The instruction of a student is carried on as follows: When he enrolls he is sent the first two instruction papers with their question papers. After thoroughly studying the first instruction paper he writes his answers to the test questions and sends his work to the Schools for examination and correction, and continues with the second paper. All corrections are noted in red ink upon the student's work, which is then returned to him with suggestions for improvement, and so on until the course is finished. The student is obliged to pass a final examination in all the subjects before a diploma is issued to him.

When a student desires assistance from his instructors he uses an "information blank" provided for the purpose, and the information is promptly given him in personal letters. If he fails to send in work within a reasonable time it is presumed that he is not progressing and he is urged to resume. A special instructor is provided for him if he so desires; thus many backward students are enabled to finish their courses. Each student, as soon as he has completed his course, is provided with a complete set of instruction papers in the form of bound volumes.

The School of Electricity, which is one of the 16 of the International Correspondence Schools, offers nine separate courses on the following subjects: Electrical engineering, electricity, electric lighting, electric railways, electric power and lighting, telephony, telegraphy and wiring and bell work. An idea of the thoroughness of these courses can be gained from the following divisions and subjects taught in the first one:

PREPARATORY DIVISION.
Arithmetic. Formulas.
DRAWING DIVISION.
Geometrical Drawing.
Mechanical Drawing (Mechanical and Electrical Divisions.)
INTERMEDIATE DIVISION.
Geometry and Trigonometry.
Elementary Mechanics.
Hydromechanics.
ADVANCED DIVISION.
Algebra. Logarithms. Pneumatics. Heat,

TECHNICAL DIVISION.

MECHANICAL SECTION.
Steam and steam engines.
Strength of materials.
Applied Mechanics. Steam boilers.
Machine design.

ELECTRICAL SECTION.
Principles of electricity and magnetism.
Electrical Measurements.
Applied electricity. Batteries.
Electric transmission.
Electric railways. Electric lighting.
Design of continuous-current dynamo-electric apparatus.
Principles of alternating-current apparatus.
Design of alternating-current apparatus.

The electrical course differs from that above in being shorter and omitting instruction in steam engines, boilers, strength of materials, applied mechanics, or general machine design, being intended for those who are already familiar with these subjects.

The electric lighting course is intended for linemen, wiremen, dynamo tenders and stationary engineers, and affords instruction in the installation and maintenance of arc and incandescent lighting systems.

The electric railway course is intended to give motormen, repair men, railway electricians and construction engineers an education which will fit them for advanced positions.

The power and lighting course is a combination of the electric railway and electric lighting courses.

The course in telephony is intended for men connected with either Bell or independent exchanges. The text books for this course were specially prepared by Mr. Kempster B. Miller, who is well known to readers of these pages.

The course in telegraphy is designed to give operators, linemen, foremen, etc., a complete knowledge of the most recent developments of the quadruplex methods of dynamo working.

The course in wiring and bell work is intended to teach gas fitters, plumbers, carpenters, etc., how to install bell circuits, burglar alarms, annunciators and special equipments for hotels, etc.

AN EFFICIENCY TEST OF A 125-H. P. GAS ENGINE.

At the meeting of the American Society of Mechanical Engineers, recently held in New York City, Mr. C. K. Robertson of Lafayette, Ind., presented a paper on the results of tests under various loads of a 125-h.p. Westinghouse gas engine located in the central station of the Merchants' Electric Lighting Company of Lafayette.

The engine is one of two similar machines using natural gas as fuel, each driving a 60-kw. two-phase 60-cycle alternator. During the time of the test, which was maintained for five hours during the night, the entire load of the station was thrown upon one engine. The time was chosen so as to include a considerable load variation in order that the performance under different conditions might be observed. The electrical load varied from 18 to 86 h.p. The engine was not put in special condition for the test in any way. The mixing valve was set to give a ratio of gas to air from 1 to 11 to 1 to 12.

All the factors of power transformation in a gas-engine plant from the gas meter to the electrical lines follow each other's variations so rapidly—there being no storage of energy as in the steam boiler—that it is possible to obtain a reliable test of but a few minutes' duration. The test was therefore divided into a series of tests of 10 minutes' duration, in each of which an observation was had at the beginning, in the middle and at the end of the period. The results may be summarized as follows, all figures being averages of the ten-minute periods:

Cubic feet of gas per hour	1268
Indicated h. p.	88.8
Brake h. p.	73.3
Frictional h. p. of engine	15.5
Mech. efficiency of engine, per cent.	79.7
Electrical output	65.5
Ratio of electrical output to indicated h. p., per cent.	70.2
Gas per indicated h. p. hour, cu. ft.	14.2
Gas per electrical h. p. hour	20.7
Thermal efficiency of engine	14.6
Thermal efficiency of plant	12.9

The brake h.p. was figured from the electrical output and the commercial efficiency of the dynamo, neglecting the belt losses. Of the two thermal efficiencies given the first is the ratio of the indicated h.p. to the heat energy of the gas consumed, and the second is the ratio of the electrical power to the same energy.

The amount of heat absorbed by the jacket was determined by measuring the rise in temperature and the weight of water passing through the jacket. The temperature of the exhaust gases was determined by a special calorimeter. This consisted of a copper ball which was heated up by the exhaust gases and then cooled by being dropped into a measured quantity of water. From the rise of temperature of the water and the known specific heat and weight of the copper ball its initial temperature was determined. The temperature of the exhaust by this method was found to be from 1000 to 1200 degrees F. Of the total number of British thermal units applied, about 18 per cent. were converted into work, about 30 per cent. were absorbed by the jacket and about 52 per cent. were exhausted.

The writer concluded his paper with some practical notes concerning the operation of gas engines and improvements that may be expected in the future, as follows:

Chief among the changes expected to give greater economy will be the substitution of solid oil in the crank case instead of oil and water as at present. It is stated on good authority that the presence of water in the oil, when exposed to the conditions met with in the cylinder, seriously injures its lubricating effect, whence come rapid wear of cylinders and bearings, and, consequently, low mechanical efficiency. Care must be exercised in the amount of oil permitted in the crank case, lest so much reach the cylinders as to carry flame over an exhaust stroke and ignite the next succeeding charge, and with it the mixture in the distribution pipe. Any considerable amount of this "back firing" has a very detrimental effect on the engine in general, and seriously interferes with good governing. Back firing may also be caused by a leaky admission valve or a leak in the caging on which the admission valve is seated. Cases have been reported where engines are running on gasoline in which a coating of burnt oil has collected on the end of the piston. This, it is thought, may come to a temperature high enough to ignite the incoming charge. At any rate, the back firing ceased with its removal.

The red glow of the exhaust pipe at night, or the red-hot condition of the copper ball used in determining the exhaust temperature, bore convincing evidence of the high temperature within the cylinder. This high temperature gives some trouble with the exhaust valves, making it necessary to watch them quite closely lest a little leak soon burn out into a hole of considerable dimension. This intense heat sometimes has caused the breaking off of the exhaust-valve stem. The use of more metal in the valves has practically ended these troubles. In a gas-engine plant the certainty of action depends upon a number of details, such as quality and time of ignition, proper compression, right proportion of gas to air, control of cylinder temperatures, etc. On one occasion sand was deposited in the jacket from the cooling water, making it impossible to cool the cylinder properly. The result was that the heat of compression furnished a high enough temperature to ignite the charge, and the engine was run for some time without the igniters in operation.

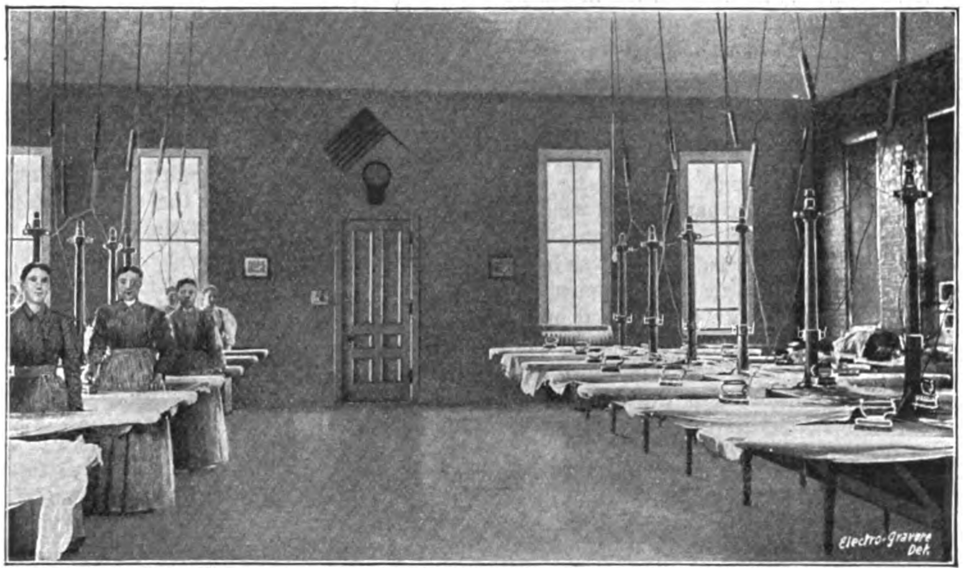
At various times the gas supply for the city has been shut off. Under such circumstances the engine, acting as a pump, has continued to draw gas from the mains, and to run through such shut offs of thirty minutes' duration.

Soon after the gasoline-vapor generator was installed, artificial gas was piped to the plant and proved so much more convenient for emergency runs that the vapor generator was not used, and at the present writing has been removed. In the warm months of summer trouble has been experienced in cooling the jacket water in the cooling tower. As a result, a motor and pump were installed at the river bank, some distance away, and the jacket water is secured from that source. As soon as the warm months are over the cooling tower is used again. Natural gas is sold to the company by meter at the rate of $.07 per thousand cubic feet.

THE USE OF ELECTRIC LAUNDRY IRONS IN AN INSANE ASYLUM.

In the laundry of the Eastern Michigan Asylum for the Insane at Pontiac, Michigan, electric irons have been substituted in place of gas irons formerly used, on account of various well-known advantages in addition to one or two which are peculiar to insane asylum service. Most of the work is done by patients of the asylum and on account of their erratic intelligence, the electric iron, with its freedom from risk of fire, is particularly valuable. Electric irons are also always of an even temperature and hence do not require the exercise of judgment in the frequent changing for a freshly heated iron. With the old system some of the patients did not know enough to change the irons when they became too cold for the work.

The installation consists of 37 8-pound irons, which are operated on a 110-volt direct-current circuit run from the power house of the asylum. The arrangement of the tables is shown in the accompanying illustration. Each main table has ironing boards projecting at right angles from both its sides. A row of ornamental wooden posts rises from the center of the main table, there being one post for each two ironing boards and for each two irons. The posts are hollow and the wires are brought up through the inside to ordinary wall receptacles. The cords from the irons are kept off from the ironing boards by spring supports from the ceilings and run from these supports to attachment plugs in the receptacles on the posts. A single-pole knife switch is placed on the side of the post within easy reach of the operator to control the current of each iron. The installation was made by the United Electric Heating Company of Detroit, Michigan.



THE LAUNDRY OF THE EASTERN MICHIGAN ASYLUM FOR THE INSANE.

In addition to the special advantages mentioned above, the electric irons do not vitiate the atmosphere, do not allow starch to stick to the bottoms, as they are always of the proper temperature, and remain highly polished by constant use. The handles of the irons are always cool. The irons are found to be in this instance more economical than the gas irons formerly used.

SINGLE-CLIP VS. DOUBLE-CLIP SWITCHES.

On this much disputed topic the following information contained in a recent bulletin of the Emerson Electric Manufacturing Company is well worth republishing:

"There is a general impression prevalent amongst the electrical trade that the latest underwriters' rules require double-clip knife switches. This impression is entirely wrong, and we quote as follows from the latest edition of the 'Supplement to the National Electrical Code':

" 'Hinges of knife switches must not be used to carry current unless they are equipped with spring washers, held by locknuts or pins, so arranged that a firm and secure connection will be maintained at all positions of the switch blades.'

"There is absolutely nothing in the rules of the National Board requiring double-clip switches. In our opinion, the single-clip switch, when properly constructed, is much better than the double-clip style, for the following reasons: The contact can be made more positive by means of spring washers. The double-clip switch requires three pieces to be exactly in line in order to procure uniform contact on both clips. It is almost impracticable to obtain this alignment. The double-clip switch takes up much more room on switchboards, and is more expensive.

"In the fall of 1897 the National Board issued Laboratory Report No. 738, requiring double-clip switches. In common with other knife-switch manufacturers, we took issue with the ruling, and, after stating the facts mentioned above, the ruling requiring double-clip switches was repealed, as the following letter shows conclusively:

"Chicago, Ill., Jan. 4, 1898.

To Manufacturers of Knife Switches:

"Please notice that changes were made in specifications given in Laboratory Report No. 738, at the recent New York conference, by which spring breaks are not required, and properly designed hinges are allowed to carry current on switches used for all potentials. The table giving minimum break distances and minimum separation of metal parts of opposite polarity was changed so as to require uniform spacings on all switches used for less than 300 volts, that is, making no distinction between 110 and 220-volt switches. Copies of the specifications changed will be forwarded you as soon as they can be received from the printer. In the meantime please accept this notice of the withdrawal of some of the restrictions.

"Very truly yours,
"Wm. H. Merrill, Jr.,
" 'Electrician.'

"The above letter shows that the rule requiring double-clip switches was repealed almost two years ago, and, in fact, was only enforced for a very short time. From our experience we recommend the use of single-clip switches in preference to the double-clip style."

ARE SLACK BELTS POSSIBLE?

What part of an electric plant gives more trouble or annoyance and requires more attention that the belts? Any engineer knows the tale: Slipping, tightening up, more stretching, never being able to retain enough initial tension on account of the everlasting stretching, and then when the stretch is seemingly all out of the belt, it will stretch just enough to slip and yet not enough to be taken up. A belt constantly stretched to its utmost limit finally becomes "dead," having lost its elasticity, for the fibers of the leather under this constant strain have been stretched out of place, and, in the majority of cases, the belt being dead, they remain displaced so long that they never recover their original position. This is not, however, due to the power transmitting strain, but is wholly due to the dead load of initial tension carried.

Every practical engineer knows that the whole evil hinges on slipping, and that the proper way to run a belt is easy or slack, for if a belt does not slip it is not necessary to keep it tight, and, consequently, no initial tension is necessary. Under these conditions the strain on the belt is simply that produced in the transmission of power, so that a non-slipping belt can run taut on the driving side and easy or slack on the idle side; or, in other words, can be at rest half the time, opportunity being thus given for the fibers, stretched under the load, to regain their position. Such a belt can never become "dead."

This has, until recently, been an ideal but theoretical condition for belts. Belt dressings have striven to reach this evil, but no mere belt dressing can do it, for the belt must not only be cured absolutely and permanently of slipping, but must regain and retain the soft, pliable and elastic state of perfect leather.

However, "Cling-Surface," sold by the Cling-Surface Manufacturing Company, of Buffalo, N. Y., a belt filler and preservative, is claimed to be bringing about the possibility of running belts slack in many large establishments, whose statements concerning its success in this direction are so concordant as to lend them great weight.

New Apparatus and Appliances

THE FALCON ATTACHING PLUG AND FLUSH RECEPTACLE.

A plug and receptacle designed for use in the universal outlet boxes on either walls or floors are illustrated in Figs. 1 and 3. The receptacle is arranged for front connections so that no slack wire need be left in the outlet box. It can be completely installed and connected with the face plate removed so as to protect the latter from being scratched during the work. The plugs are provided with fuse connections for both poles and are interchangeable in the receptacles without diminishing the electrical contact, as the variation in the moulded porcelain is overcome by a stiff contact spring. These devices are made by the Falcon Electric Manufacturing Company of New York City.

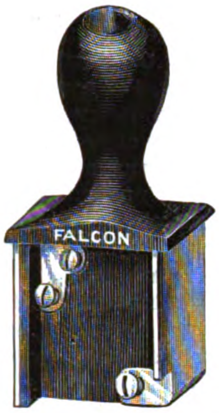


FIG. 1.—THE FALCON PLUGS.

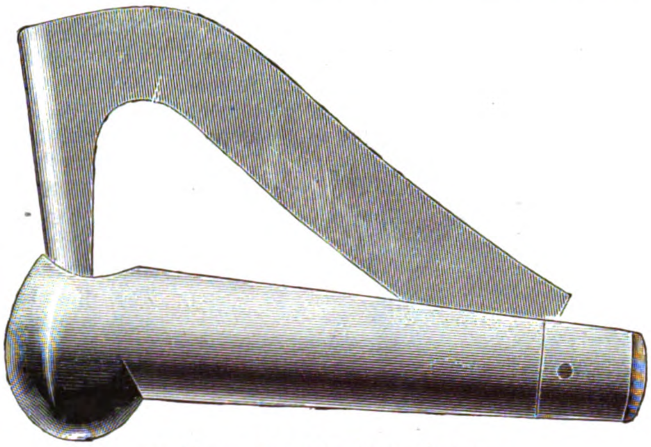


FIG. 2.—A FOLDING FLOOR GROOVER.

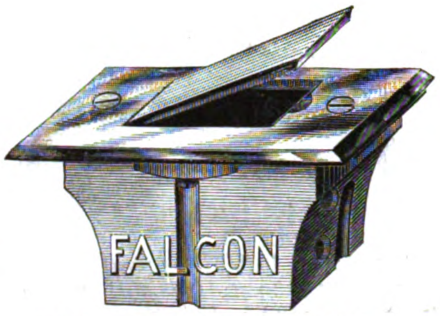
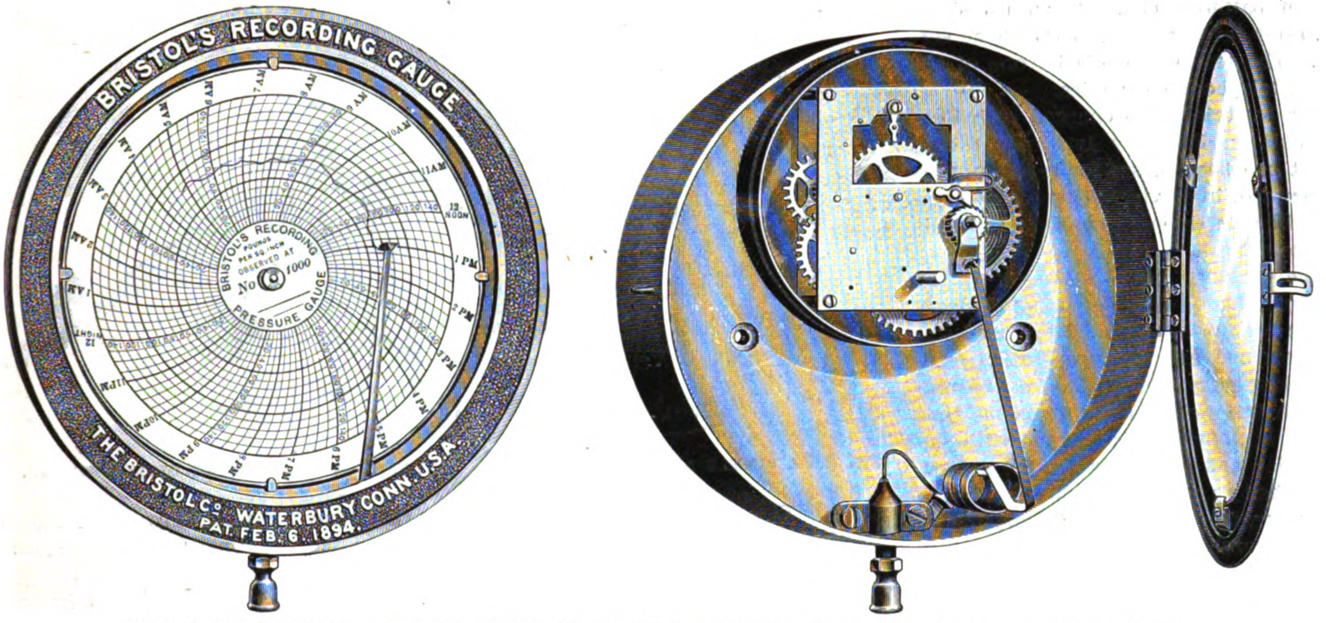


FIG. 3.—THE FALCON RECEPTACLE.

A BRASS HANDLE FOLDING POCKET FLOOR GROOVER.

The Western Electric Company is placing upon the market a new floor groover, the blade of which is very similar in appearance to the stiff-handled floor groover which has been used for some time. A novel and peculiar feature of this new floor groover lies in the fact that the blade can be folded back into the handle like the blade of a pocket knife. The point fits into a socket, the edge of which comes in contact with the back of the floor groover, thus preventing the point from being worn. When folded the greatest dimension is three and one-quarter inches, so that it can be carried handily in the pocket. If the tool is thrown into the handbag of the workman with other tools, the point is protected by the socket into which it fits, thus making it impossible for the other tools to spoil the edge. The handle of the floor groover is made of brass and is of a convenient size and shape which fits the hand. The illustration, Fig. 2, shows the floor groover closed.


BRISTOL'S RECORDING GAUGE
BRISTOL'S RECORDING PRESSURE GAUGE
No 1000
THE BRISTOL Co WATERBURY CONN. U.S.A.
PAT. FEB. 6. 1894.

FIGS. 4 AND 5.—FRONT AND REAR VIEWS OF THE NEW BRISTOL ROUND-TYPE RECORDING STEAM GAUGE.

BRISTOL'S ROUND RECORDING PRESSURE GAUGE.

The illustrations, Figs. 4 and 5, show exterior and interior views of a new round recording steam-pressure gauge that is being placed on the market by the Bristol Company of Waterbury, Conn. This new form has been designed to meet a demand for a recording gauge at a lower price than the standard gauges of the same company.

A special feature of the round form is that the dial is located slightly eccentrically to the main body of the case, thus allowing sufficient space on the lower side of the dial for the pen arm to pass out between the dial and the case.

Fig. 5 shows the interior construction of the instrument and the extreme simplicity upon which its accuracy and durability depend to a large degree. The pen arm is directly attached to the free end of a tube of flattened cross-section which is bent into a helical form. The tendency of pressure applied is to straighten or uncoil the helical tube, which causes the pen arm to move over the range of the chart without the necessity of any intervening multiplying devices.

In order that the advantages of using recording pressure gauges and other recording instruments may be more generally appreciated, the Bristol Company is filling orders for these instruments with the privilege of returning at end of thirty days' trial if not perfectly satisfactory.

FEDERAL BATTERY SALTS.

There is now being put on the market by the Federal Battery Company of New York City a new excitant for use in open-circuit batteries in place of sal-ammoniac. The new material is called "Federal Salts." The manufacturers claim that it will raise the voltage of almost every battery now using sal-ammoniac, giving a voltage of from 1.6 to 1.9 volts, and in addition giving 33 per cent. more current or longer life with the same current. It does not crystallize or form creeping salts on the carbons or zincs, which thus remain clean throughout the life of the battery, and do not require soaking when renewals are made. It is also claimed that the new material gives improved recuperative action. The zincs require amalgamation to prevent local action just as they do with salammoniac.

Federal Salt.
PATENTED
No. I.
KEEP DRY.
CHARGE FOR
SMALL BATTERY
Federal Battery Co.
NEW YORK N.Y.
Use Amalgamated Zincs with Federal Salt.
FEDERAL SALT
PATENTED

FIG 6—A PACKAGE OF FEDERAL SALT.

The following is an extract from a report of batteries charged with Federal salt, after seven months of telephone service. The test was made by one of the largest telephone companies:

"Our batteries were charged with Federal Salt on February 1st, and at time of test had been in use for seven months and are still in service. There is no crystallization or creeping salts on the cells at time of test.

"The readings were taken when the telephone hook was off, reading every minute for five minutes. The hook was then returned, and the recuperation readings taken every minute also for five minutes. A test was made at the same time on new Leclanche cells charged with sal-ammoniac and used only for these tests, having had no previous work.

"The readings of one 'phone out of forty in service are given below, as well as those of the new sal-ammoniac cell under the same test. Three cells were used per 'phone in both tests:"

Federal Salt. Discharge.				Federal Salt. Recuperation.			
0	Minutes	4.30	Volts.	5	Minutes	4.25	Volts.
1	"	4.20	"	4	"	4.25	"
2	"	4.15	"	3	"	4.25	"
3	"	4.05	"	2	"	4.22	"
4	"	3.95	"	1	"	4.20	"
5	"	3.90	"	0	"	3.90	"

Zincs eaten about one-third after seven months on phone:

Sal-ammoniac. Discharge.				Sal-ammoniac. Recuperation.			
0	Minutes	4.24	Volts.	5	Minutes	3.55	Volts.
1	"	3.10	"	4	"	3.43	"
2	"	2.40	"	3	"	3.20	"
3	"	2.10	"	2	"	2.91	"
4	"	1.95	"	1	"	2.62	"
	"	1.90	"	0	"	1.90	"

Federal salt is sold in packages similar to that shown in Fig. 6, and another material entitled "Federalite," is sold in bulk. This is claimed to be better than sal-ammoniac, but not equal to Federal salt. The same company also makes batteries specially adapted to the use of this new material.

THE WILLARD AUTOMOBILE STORAGE BATTERY.

The general features of the Willard battery made by Sipe & Sigler of Cleveland, Ohio, are well known. The plate consists of a single sheet of pure rolled lead, on both sides of which are formed thin upwardly and outwardly sloping shelves about ¼ inch wide and 1/32 inch thick. The active material is produced by electro-chemical means and is not applied in the form of a paste. For automobile use these plates are assembled in hard rubber jars with glass covers, by means of which the condition of the cells can be determined at any time and any lowering of the electrolyte below the top of the plate can be promptly seen and corrected. The plates are separated from each other by hard-rubber sheaths corrugated, ribbed and slotted, so that they will not materially increase the internal resistance.

Owing to the integral character of the plates, as each plate consists of one piece, the output per pound of weight can be made considerable. With the Willard battery, however, life is not sacrificed for capacity, the weight being made sufficiently light only to make the vehicle practicable. For instance, a 50-pound cell gives 168 ampere hours at a three-hour discharge rate and 206 ampere hours at a six-hour discharge rate.

Owing to the large area of the plates both the discharge and the charging rates can be made very high, in fact it is allowable to charge at such a rate as to fully recharge the battery in 45 minutes. This must be done with a diminishing current. For instance, the 50-pound cell mentioned above would be charged for 20 minutes with 356 amperes, for the next five minutes with 254 amperes; the next five 178 amperes, the next ten 76 amperes, and the final five minutes 26 amperes, making a total charge of 170 ampere hours. On account of this diminishing rate the battery is charged to practically 90 per cent. of its full capacity in only half an hour. The diminishing current means practically a charge at constant potential, the low back e.m.f. at the beginning of the charge allowing more current to flow than does the back e.m.f. at the end of the charge.

This high rate of charging is quite an important achievement in the automobile industry, as it allows vehicles to be recharged without changing batteries and without a serious loss of time.

For a specified amount per year Messrs. Sipe & Sigler offer to enter into a maintenance guarantee with manufacturers of automobiles and even with individuals using carriages operated by Willard batteries.

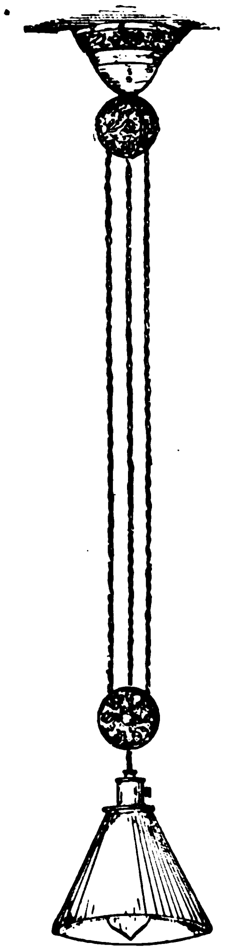


FIG. 7.—A SIMPLE ADJUSTABLE HANGER.

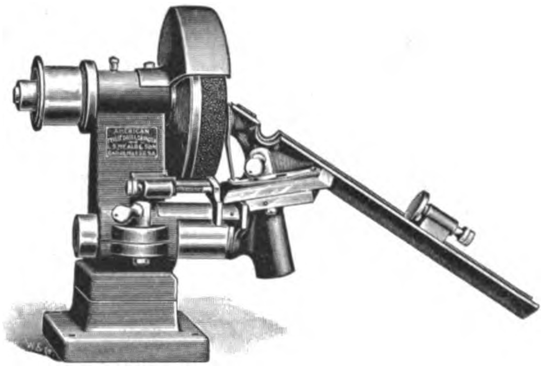


FIG. 8.—THE AMERICAN DRILL GRINDER.

THE "TWO BALLS" ADJUSTABLE HANGER.

As the name and the illustration, Fig. 7, indicate, this device consists simply of two spherical balls which take up more or less of the lamp cord by a change of their distance from each other. Each ball contains a hard-fiber flanged pulley around which the cord passes, thus giving an insulating material in contact with the cord. The cord from the rosette or fixture is made fast to the upper ball, holding it at a fixed distance from the outlet, and thence runs around the pulley in the lower ball and up and around the pulley in the upper ball and then to the socket. The cord from the upper ball to the socket is not attached in any way to the lower ball, so that when the lamp is pulled off to one side the lower ball remains hanging vertically below the upper one. The weight of the lower ball is, of course, made equal to twice the weight of the socket and attachments in order to balance it. The device is made by M. I. Vought of La Crosse, Wisconsin, in several styles of finish.

THE AMERICAN TWIST DRILL GRINDER.

A drill tends to follow its point, and if this is not in the center the longer lip sweeps around and cuts a rough, coarse hole much larger than the true size, one lip does all the work and very soon gets dull. This can be avoided by using a drill grinder. The machine shown in bench form in Fig. 8 is made by L. S. Heald & Son, Barre, Mass. It will grind drills having diameters from ⅛ inch to 2¼ inches, either flat, three-lip or four-lip, as well as chucking reamers. The machine is fitted with a safety stop, with caliper jaws which are adjusted horizontally, with an improved lip rest for all sizes, and is so arranged that the points of all drills rise to the same height. The clearance may be varied if desired.

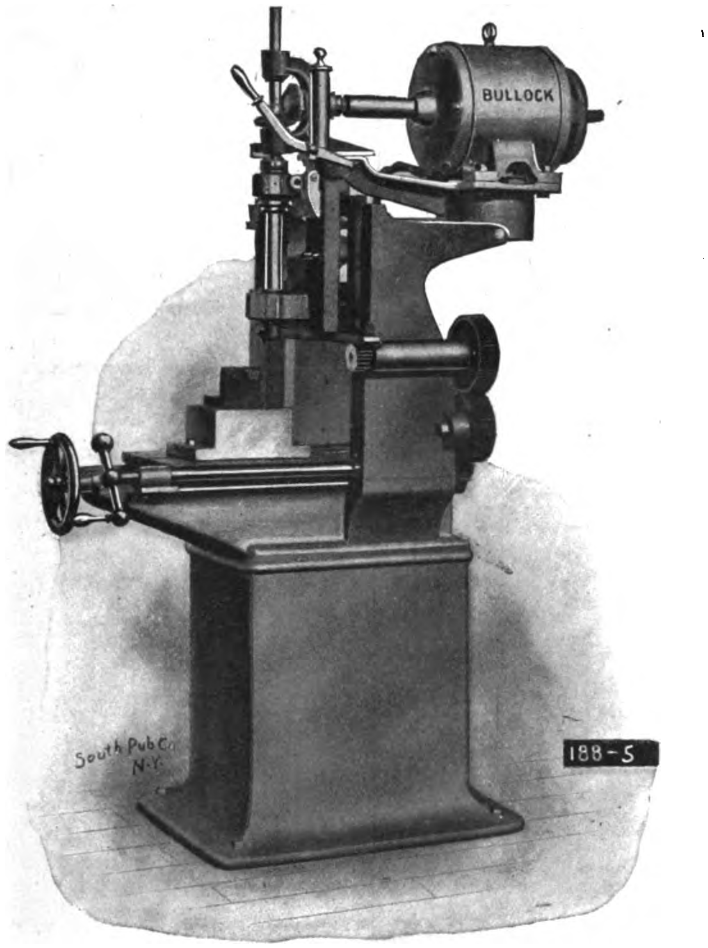


FIG. 9.—A PROFILING MACHINE WITH MOTOR MOUNTED ON TURN TABLE.

A MOTOR-DRIVEN PROFILING MACHINE WITHOUT BELTS.

A profiler is a difficult machine to drive electrically without intermediate belting, owing to the fact that the spindle is constantly moving back and forth with the shifting of the carriage. The motor might be mounted directly upon the spindle, but it adds considerable objectionable weight to the carriage. The Bullock Manufacturing Company has overcome the difficulty by mounting the motor on a rotatable base and connecting the motor shaft to the bevel gears driving the spindle by means of a splined shaft and sleeve. The whole arrangement is shown in Fig. 9.

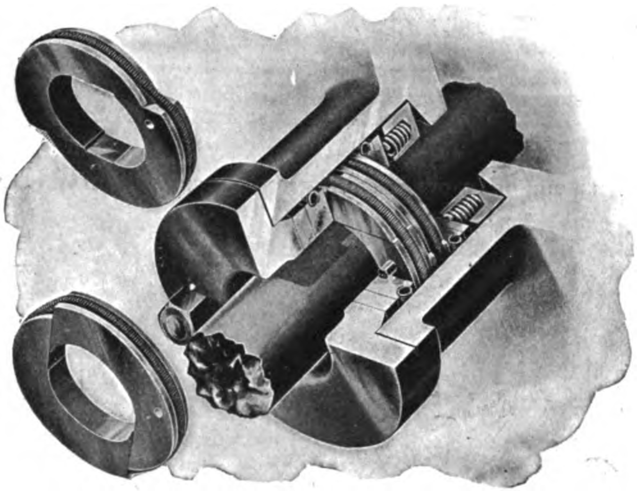


FIG. 10.—HARTHAN'S METALLIC ROD PACKING.

As the carriage travels back and forth across the machine the motor turns upon its table so as to keep the gears in mesh and the splined shaft takes up the variations in the distance between motor and spindle.

The motor is described in greater detail in bulletin No. 0435, which may be had by addressing the company at Cincinnati, Ohio.

HARTHAN'S METALLIC ROD PACKING.

Some of the requirements of metallic packing for piston rods, valve rods, etc., are as follows: It should be so constructed that it can be applied to the rod without disconnecting from the cross head; it should be made to go in the stuffing box in place of the ordinary fiber packing; the parts which bear against the rod must be made of a metal whose melting temperature is high enough above that produced by the steam and friction of the rod to prevent any possibility of softening, and yet this metal must not be hard enough to cut the rod under any circumstances.

The packing illustrated in Fig. 10 is made by the Reeves Machine Company of Trenton, N. J., to meet these and other requirements. As may be seen by a glance at the illustration, the packing consists of a series of rings split into halves by cleavage planes tangent to the rod to be packed. These half rings are held lightly together by means of coil springs lying in grooves around them, suitable pressure against the rod being given by the force of the steam on the outside of the rings. The lines of cleavage of the separate divided rings break joint with each other and the rings are forced against each other by short-coil springs, two of which are shown in the section.

The claims are made that this packing will work successfully on badly scored rods as long as there are no shoulders to open the packing, and also that it shows much lower friction than fiber packing.

THE HORNISH BOILER CLEANER.

In the description of various boiler cleaners of the blow-off type which appeared in the American Electrician of last November, one interesting modification of such cleaners, invented by Mr. F. W. Hornish, was omitted. This cleaner consists essentially of a suitable draw-off device and may be used either in connection with a skimmer basin for surface blow offs, or directly in the mud drum or a water leg of the boiler, wherever sediment tends to collect. Fig. 11 shows the arrangement in an ordinary mud drum.

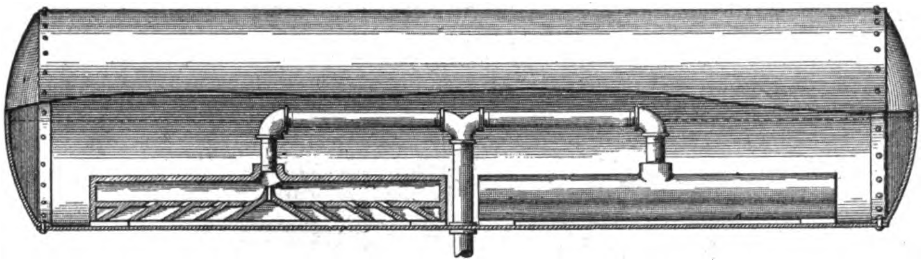


FIG. 11.—THE DRAW-OFF MECHANISM OF A HORNISH BOILER CLEANER.

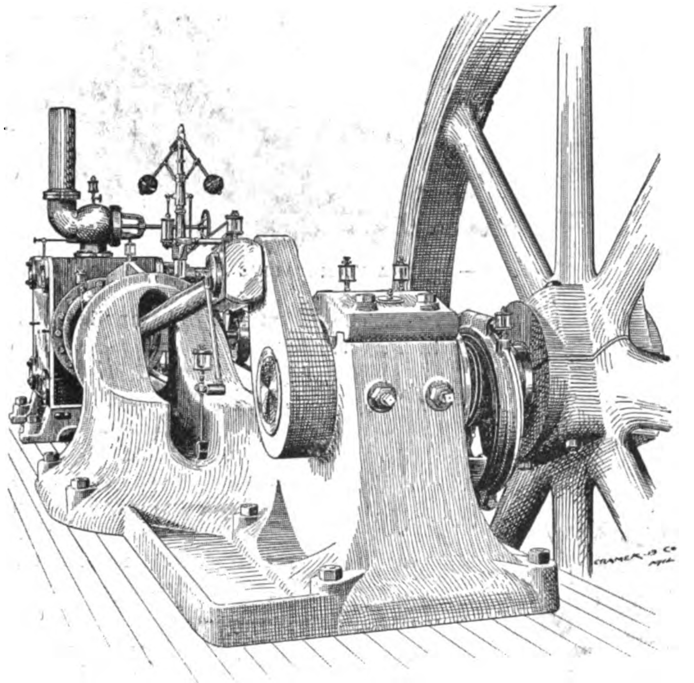


FIG. 12.—A VILTER CORLISS ENGINE.

It will be seen that the draw-off consists of a head open on its under side, with a series of inclined flanges or partitions, which forms transverse spaces or "suckers." The head is piped to an outlet pipe which may be governed by a hand valve or an automatic blow-off cock. The boiler may be fitted with one of these devices in a skimming basin at the water level to act as a surface blow-off, and with others where a heavy sediment tends to deposit in places low and of slow circulation.

The device is being put upon the market by the Hornish Mechanical Boiler Cleaner Company of Chicago. It was recently (September 12th, 1899) broadly patented, one claim reading "A mechanical boiler cleaner comprising a stationary basin arranged within a boiler and having a depression in which the sediment collects, and a draw-off device for blowing out the sediment from the basin."

THE CORLISS ENGINES OF THE VILTER MANUFACTURING COMPANY.

Fig. 12 shows a view of an engine made by the Vilter Manufacturing Company of Milwaukee, Wisconsin, for which the following meritorious points are claimed. The frame is of the girder type, cast in one piece from the cylinder end to the pillow block. The cross-head slides are bored so that in case of a settling of the outboard bearing the pin will not heat. The cross-head shoes are lined with babbit metal and are adjustable by screw and wedge take-up mechanism. The connecting rod is made of hammered wrought-iron, having solid heads with brass box, lined with babbit, and wedge adjustment for crank-end, and solid head with brass box, and wedge adjustment for cross-head end. The hooks on the release gear are heavy brass castings with hardened-steel wearing surfaces, which are interchangeable; and the position of the hook is so arranged that it will work without the aid of a spring. The spring is put there as a safeguard in case of edges and blocks wearing. The dash pots used are of a new style, enclosed on the top so as to be dust proof, and are run without the old-style leather cup packing. The enclosure renders them noiseless.

WEINLAND TUBE CLEANERS.

The accompanying illustration, Fig. 13. shows a Weinland mechanical tube cleaner in position ready for work. It is securely attached to boiler front in a simple and original manner without any special preparation. It is not even necessary to remove the doors. The machine may be driven by any suitable power of [illegible] to 8 h.p., according to conditions. In the case illustrated a 5-h.p. electric motor was used.

The cutter heads in the machine are of peculiar construction, but so arranged as to remove the heaviest and hardest scale and thoroughly clean the tubes of every particle without doing the least injury to the tubes themselves.

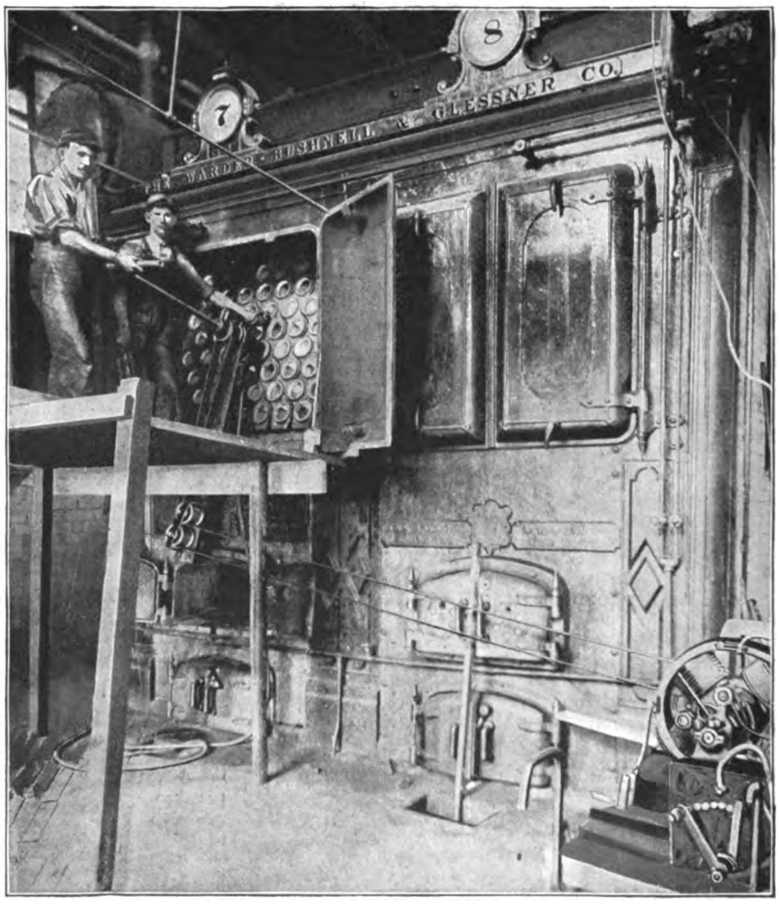


FIG. 13.—A WEINLAND TUBE CLEANER AT WORK.

American Electrician.

Vol. XII. New York, February, 1900. No. 2

THE TRANSFORMATION OF NIAGARA POWER INTO THREE-WIRE DIRECT CURRENT BY THE BUFFALO GENERAL ELECTRIC COMPANY.

With Complete Description of Circuits and Explanations of Unusual Alternating-Current Phenomena Involved.

As noted in the January issue of the American Electrician, the Cataract Power & Conduit Company, which is the distributor and vendor of Niagara power in Buffalo, delivers 3000 h.p. from its sub-station No. 3 to the central station of the Buffalo General Electric Company, which said sub-station immediately adjoins. This central station resembles a large majority of the others throughout the country in that it delivers the usual four classes of service, constant current for arc lights, 60-cycle alternating current for the scattered incandescent lights, 500-volt current for motors, and 220-volt three-wire direct current for the downtown incandescent lighting. The station is, however, unique and unlike all others in that there are no steam or hydraulic prime movers, all mechanical power being obtained from alternating-current motors supplied from the Niagara system. In this respect the station resembles transforming sub-stations of long-distance transmission systems carrying central station loads, being in fact nothing but an elaborate and complex sub-station of its kind, the largest in the world, and appropriately termed a transforming central station.

Of the general construction of the station itself and of the arc lighting sets, the alternating-current motor generators and the power service rotary converters, but little need be said here, as these have been thoroughly described in previous issues of electrical journals. The unique

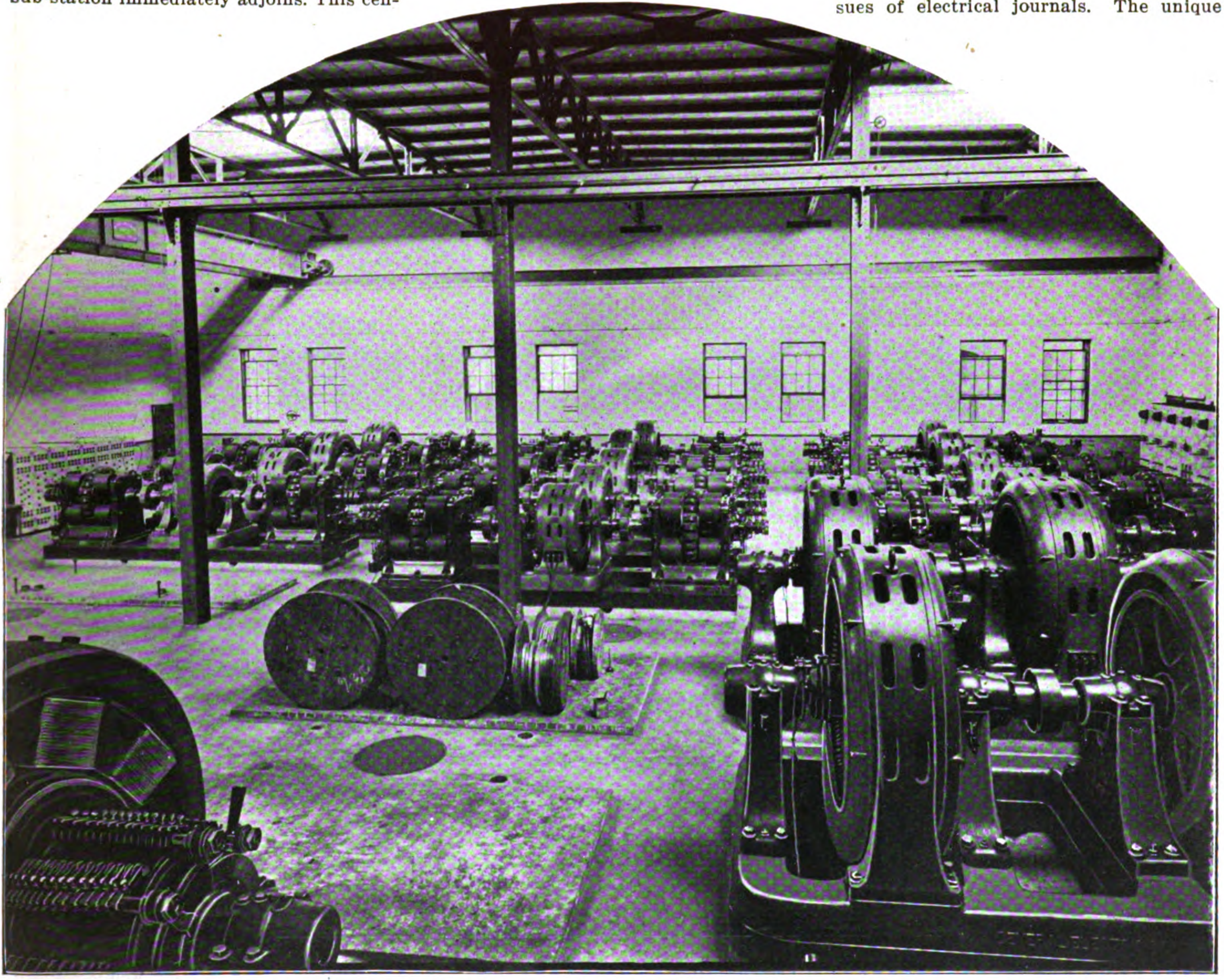


FIG. 1.—THE TRANSFORMING CENTRAL STATION OF THE BUFFALO GENERAL ELECTRIC COMPANY.

In the background are fourteen 250-light motor-driven arc sets. To the right are the 25-cycle to 62½ cycle alternating motor generators. To the left one end of the motor generator for the direct-current three-wire service.

equipment, however, for the conversion, regeneration and storage of power in the form of 220-volt direct current, which equipment differs considerably from that of Edison companies operating high-tension systems, has never been fully written up and forms the subject of the following description.

The original apparatus for supplying this load consisted of two 100-kw. 125-volt rotary converters which were run in series with each other on their direct-current ends across the three-wire system in the usual way. These machines were installed with the original equipment of the station and started about the first of January, 1899. One of these rotaries is illustrated in Fig. 2, which shows the rather remarkable appearance of a machine of this kind for such low voltages. The commutator, it will be seen, has practically the same length and diameter as the armature itself. This is due to the fact that a three-phase rotary converter can be made to deliver considerably more current without overheating than the same armature and fields would generate if mechanically driven as a dynamo. Thus the machine requires a commutator considerably enlarged above even the size necessary for a generator at this low voltage.

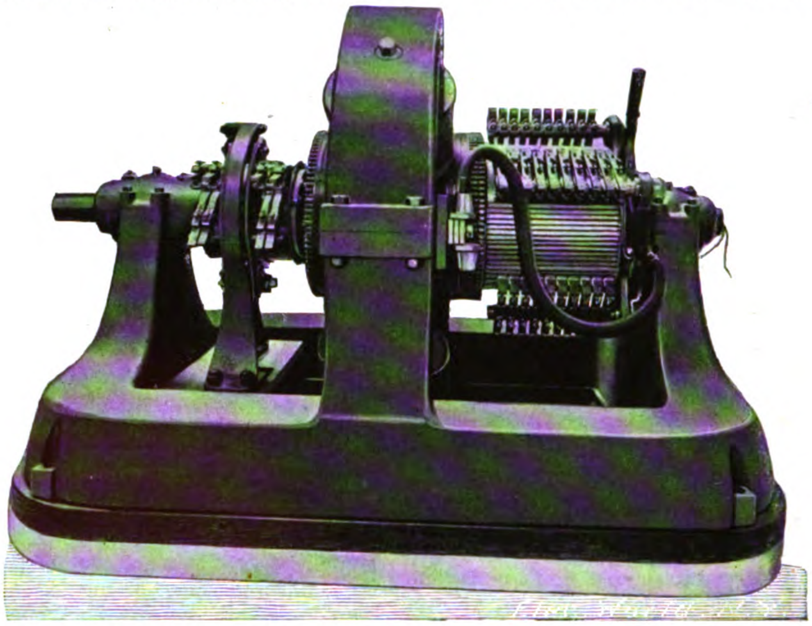


FIG. 2.—ONE OF THE 100-KW. 125-VOLT ROTARY CONVERTERS.

An unfortunate peculiarity of rotary converters in service of this kind is the fact that the voltage of the direct-current output is always exactly proportional to the alternating voltage impressed upon the collector rings. If the latter varies, due to changes of load and drop in the alternating-current system, the direct voltage varies with it, thus requiring as perfect regulation—so far as momentary changes of pressure are concerned—in the alternating system as is needed for the direct-current incandescent lighting. On this account—and in spite of the greater cost and lower efficiency of motor generators as compared with equivalent rotaries—the additional transforming apparatus which has been installed during the last year is in the form of a motor generator in which the direct-current pressure is quite independent of the alternating-current pressure, and dependent only on the speed of the machine, which in turn is exactly proportional to that of the alternating-current generators at Niagara and independent of the varying drop in the line, sudden reactive drops in the transformers when alternating-current motors are started, and similar disturbing factors.

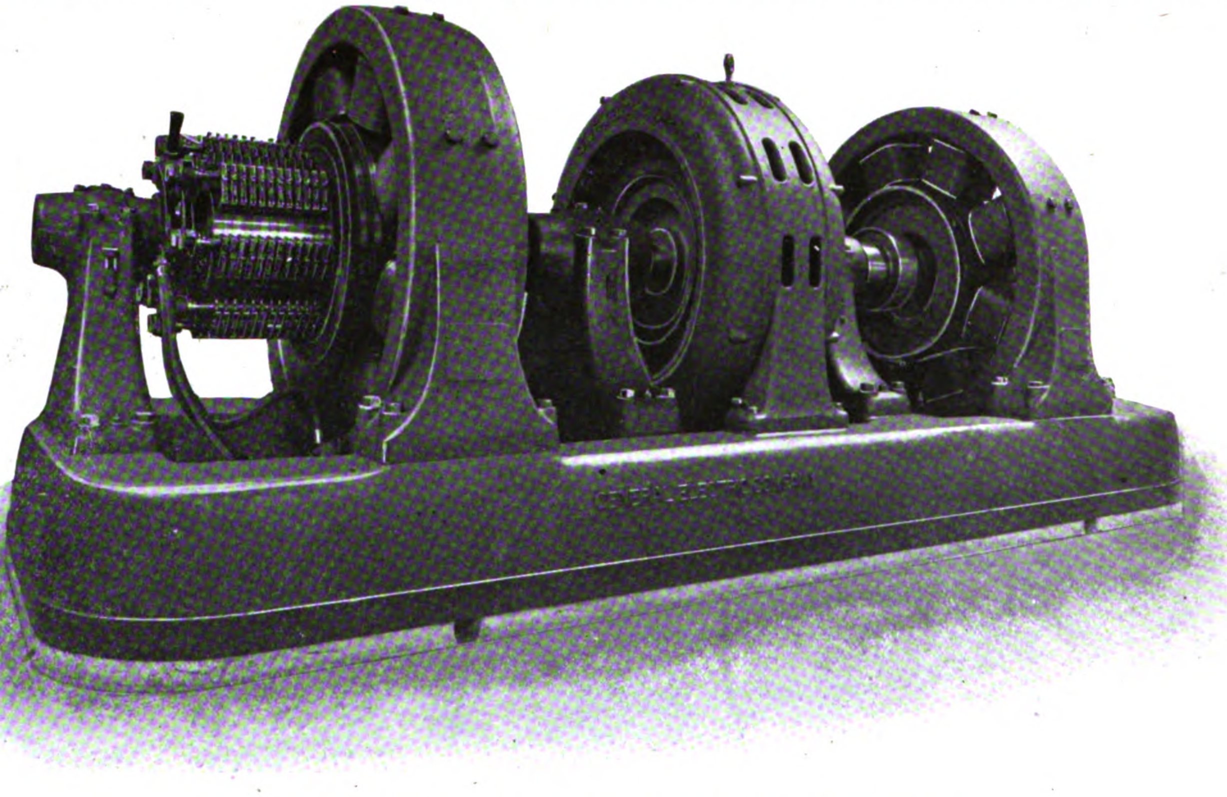


FIG. 3.—THE 400-KW. THREE-PHASE TO THREE-WIRE MOTOR-GENERATING SET.

The new motor generator, which is illustrated in Fig. 3, consists of a 425-kw. or 565-h.p. three-phase revolving-field motor direct coupled to two 200-kw. shunt-wound generators which are rated at any pressure from 130 to 190 volts. As the illustration indicates, the set is mounted on one bed plate, the motor being in the center, and the shaft being supported on four bearings. There are two rigid flange couplings mounted close under the overhanging barrel windings of the direct-current generators. The illustration gives a good idea of the relative weight of alternating-current and direct-current machinery. The alternating-current motor appears to be no heavier than one of the two direct-current generators which it drives. To be sure, the conditions are favorable for the alternating-current machine since its voltage is a convenient one for winding and insulation, while that of the direct-current machines is so low as to require large commutators.

The general arrangement of the circuits of these machines is interesting, as it is probably the first time in the history of electrical engineering that motor generators, rotary converters, and a storage battery have been run in parallel with each other on a three-wire load, and also because the circuit switching, controlling and indicating devices have been worked out on novel lines. On this account the switchboard and its circuits will be described in detail.

The controlling panels of the whole alternating-current three-phase to direct-current three-wire system, including the panels for the storage battery and those for the outgoing feeders are combined in one handsome switchboard, a view of which appears in Fig. 4. The general scheme of the circuit, with minor details omitted, is shown in the diagram, Fig. 5, in which the actual arrangement of the switches on the board is followed so far as possible without causing too great a confusion in the diagram.

All power is received in the central station of the Buffalo General Electric Company in the form of three-phase current under a pressure of 352 volts, this pressure being chosen owing to its direct availability in 500-volt rotaries and its convenience for station wiring. The three 352-volt three-phase bus bars are indicated in the upper left-hand corner of the diagram. For the 125-volt rotaries this pressure must necessarily be stepped down, which is accomplished by means of three 75-kw. 352-volt to 80-volt transformers, indicated just below the three-phase bus bars in the diagram.

To aid in the regulation of the voltage of the rotaries an I. R. T. regulator is connected in the 352-volt primary leads to the transformers. These transformers and the regulator are mounted on a gallery above and behind the switchboard shown in Fig. 4, and the operating handle which is connected to the moving part of the I. R. T. regulator by a sprocket chain may be seen on the sub-base of the left-hand panel of the board. Above this handle on the same panel may be seen the various switches and two ammeters in the alternating-current lines to the rotary converters, this panel being the alternating-current panel for these two machines. The three upper switches are primary switches, indicated in the diagram of connections just below the regulator,

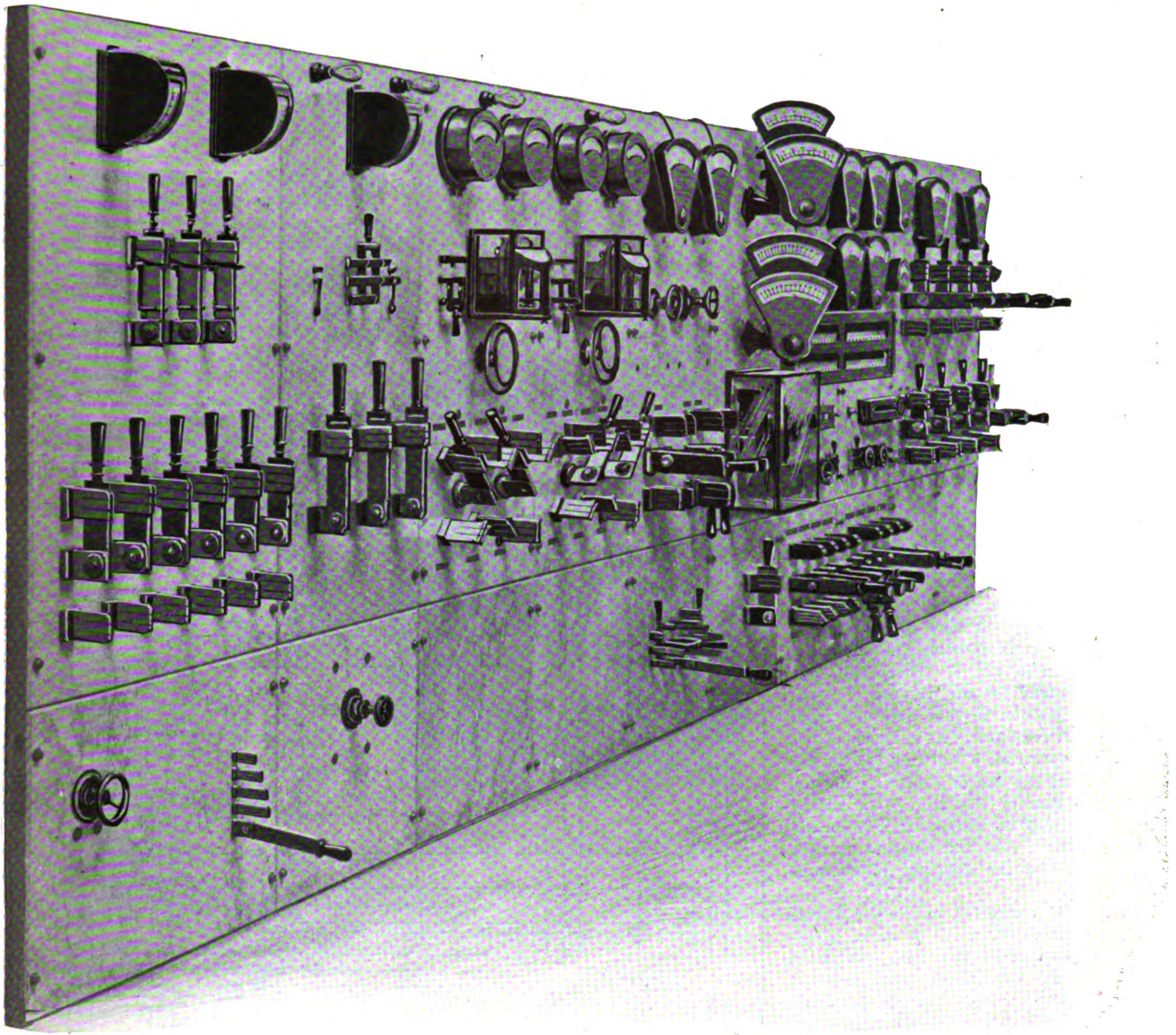


FIG. 4.—THE SWITCHBOARD CONTROLLING THE WHOLE OF THE THREE-PHASE TO THREE-WIRE SYSTEM.

The panel in the left foreground handles the a. c. ends of the two rotaries; the next the a. c. end of the motor generator; the next two the d. c. ends of he two rotaries, etc. Further along are storage-battery and feeder panels.

and are, as the illustration shows, of the quick-break type. The two edgewise instruments at the top of the panel are alternating-current inclined-coil ammeters connected in the secondary circuits of the step-down transformers, one into one leg of rotary No. 1 and the other into the corresponding leg of rotary No. 2 so that the instruments indicate respectively the current flowing into each machine. All fuses are of the open aluminum-link type and are mounted behind the board. The six single-pole double-throw switches across the center of the panel are cut in between the secondary windings of the step-down transformers and the collector rings of the rotaries, and are wired up in the way indicated in the diagram. A glance at the latter shows that the secondary turns of each transformer are divided into two equal parts which are not electrically connected to each other and that these two halves of the secondary windings are connected up in three electrically separate deltas; one of these deltas is for one rotary and the other for the other rotary. The reason of this is that the rotary converters are as a rule run in series with each other on the direct-current end so that it is impossible to run them electrically in parallel with each other on the alternating-current end, although on account of their being supplied from the same transformers they are what might be termed magnetically or inductively in parallel with each other.

The leads from the two secondary deltas run down to the upper clips of the switches through three-phase reactive coils, there being two sets of these coils, one for each rotary, mounted also upon the gallery. A view of the rear of one of these coils showing the construction is given in Fig. 6. These coils are provided chiefly for the purpose of regulation in addition to that obtained from the I. R. T. regulator. At the risk of being too theoretical, a word or two of explanation of the use of reactive coils for the regulation of the voltage of rotary converters may be warranted here on account of the recent introduction of such apparatus, and the difficulty in comprehending it.

The rotary converter, unlike the direct-current generator, gives a d. c. pressure independent of the field excitation so long as the alternating pressure remains the same, but proportional almost exactly to the incoming alternating voltage. Thus to change the voltage of the direct-current output the alternating voltage supplied must be changed correspondingly. This can be done by means of induction or transformer boosters such as the I. R. T. regulator as used in this case, or by means of reactive coils in conjunction with changes or the field strength of the rotary. These reactive coils, as shown in the illustration, are simply series windings on laminated-iron cores, and in this case the three cores of the three phases form mutual magnetic returns for each other. These coils introduce self-induction into the alternating-current cir-

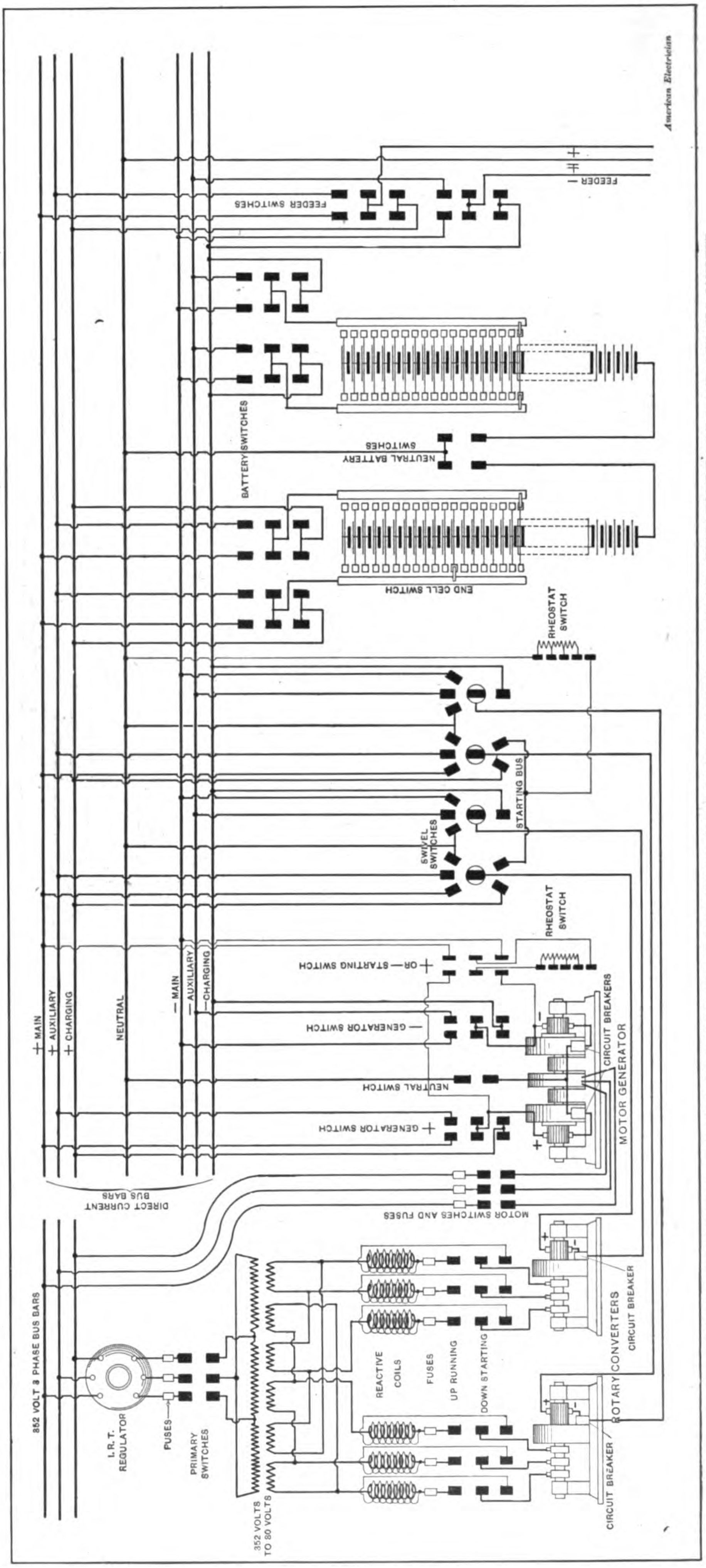

American Electrician
FEEDER +
FEEDER −
FEEDER SWITCHES
BATTERY SWITCHES
NEUTRAL BATTERY SWITCHES
END CELL SWITCH
RHEOSTAT SWITCH
STARTING BUS
SWIVEL SWITCHES
RHEOSTAT SWITCH
+ OR — STARTING SWITCH
— GENERATOR SWITCH
NEUTRAL SWITCH
+ GENERATOR SWITCH
CIRCUIT BREAKERS
MOTOR GENERATOR
+
−
+ MAIN
+ AUXILIARY
+ CHARGING
NEUTRAL
— MAIN
— AUXILIARY
— CHARGING
DIRECT CURRENT BUS BARS
MOTOR SWITCHES AND FUSES
352 VOLT 3 PHASE BUS BARS
I. R. T. REGULATOR
FUSES
PRIMARY SWITCHES
352 VOLTS TO 80 VOLTS
REACTIVE COILS
FUSES
UP RUNNING
DOWN STARTING
CIRCUIT BREAKER
ROTARY CONVERTERS
CIRCUIT BREAKER

FIG. 5.—THE GENERAL SCHEME OF THE CIRCUITS OF THE THREE-PHASE TO THREE-WIRE APPARATUS, WITH INSTRUMENTS AND DETAILS OMITTED.

cuits and this self-induction can be utilized by means of leading or lagging currents to give a boosting or depressing effect upon the voltage. The leading and lagging currents can be introduced by strengthening or weakening the field excitation of the machine. If the field of the rotary is strong, currents leading the impressed e.m.f. are drawn through the reactive coils and set up therein an inductive counter e.m.f. which, on account of its phase relation, adds to the original impressed e.m.f. If the field of the rotary is weak, lagging currents are drawn through the reactive coils and the inductive counter e.m.f. swings around so that it opposes the impressed e.m.f. and lowers the voltage. The result, so far as practical operation is concerned, is about the same as in direct-current dynamos, i. e., the field of the rotary is strengthened to increase the voltage and weakened to lower the voltage. Compound winding is used for the same purpose. By means of the reactive coils in the station of the Buffalo General Electric Company a 12½ per cent. range of voltage can be obtained, the same range being also obtainable from the I. R. T. regulators. This gives a total available range of 25 per cent.

Referring again to the diagram, it will be seen that each reactive coil has two windings, one represented by a heavy inner wire and the other by a lighter outer wire. The heavy inner wire goes straight down through the fuse to the upper point of the corresponding switch, while the other wire is connected in circuit with the lower point of the double-throw switch. The two windings are coiled around the same cores, as the photographic illustration of the reactive coil shows, and are connected in such a way that when the switches are down current is drawn through the two in series with each other so as to greatly increase the choking effect of the coils. When the switches are thrown up one winding is cut out and only that represented by the heavier line in the diagram is left in the circuit.

This is for the purpose of using the same reactive coils for obtaining the increased choking effect desirable for starting the rotaries without too heavy a demand upon the line, these rotaries being provided with this provision for starting from the alternating-current end for use when direct current for starting purposes may not be at hand. A rotary converter or any other synchronous motor, when started in this way from the a.c. end is practically an induction motor, the rotating magnetism set up by the polyphase alternating currents in the armature conductors traveling across the pole faces and setting up foucault currents in the iron, which with the lag due to hysteresis give a drag upon the armature exactly like that of an induction motor; but the absence of a proper closed circuit secondary makes the drag very weak. If the machine is connected through its collector rings directly to the a. c. mains a tremendous overload tends to flow just as a tremendous direct-current overload would flow through the armature were it connected across the constant-potential mains at standstill. On this account a reactive coil or voltage-lowering compensator which will check the current down to that required for starting—which is generally two or more times full load current—must be inserted to prevent too severe a disturbance of the voltage in the alternating-current system.

On account of the fact that an overload current is required to start the rotaries the fuses are connected in circuit in such a way that they are cut out when the switches are in the down or starting position, and are only in circuit when the switches are in the upper or running position. The reactive coils themselves are as the diagram indicates, made up with their running windings of a larger cross-section than their starting windings, since the latter are only in use for a brief interval. Of the starting windings only the ends, which, in the coils themselves, are wound within the running windings, appear in the illustration above. The motor starting and running switches throughout the station are made to conform with each other in this respect, that the starting position is down and running position is up. At the time the photograph for Fig. 4 was taken these switches of the 125-volt rotaries were closed in the running position.

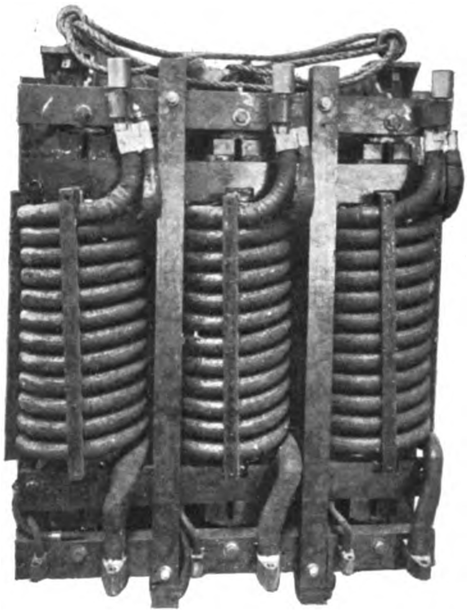


FIG. 6.—A THREE-PHASE REACTIVE COIL, WITH STARTING AND RUNNING WINDINGS.

Referring now to the direct-current side of the system, it will be seen from the diagram that the switchboard carries seven bus bars, one common neutral, three positive and three negative. Both polarities have a main and an auxiliary and what is termed a charging bus bar. Although the name used indicates that the latter is specially connected with the battery in some way differing from the others, this is not the case, the connections to all machines, feeders, etc., being the same from one bus bar as from another, except that the switches to and from the charging bus are, as a rule, provided of higher conductivity. The three buses provide for three different voltages, and by virtue of the arrangement described below any one or more of the machines, the battery and any one or more feeders may be separately, or in any combination, connected to any one or more of the bus bars according to the demands of the service.

The connection of the direct-current ends of the rotaries to the bus bars is made through a peculiar type of switch, shown on the third and fourth panels of the switchboard, and termed a swivel or pivot switch. It is in principle virtually an extension of the double-throw switch idea, to make the switch what might be termed quadruple or quintuple throw. The central point of the switch, on which the knife blade is hinged, is, in turn, pivoted or swiveled, so that the blade may be rotated in a plane parallel with the face of the board to make the blade enter any one of four or five jaws or clips. As indicated on the diagram, the positive switch of each rotary is five throw, while the negative switch is four throw.

The purpose of this unusual construction is to make it possible to run either rotary or both on either the positive or negative sides of the system. Many of the larger downtown loads of the city of Buffalo are connected up on two wires between the neutral and one of the outer conductors of the three-wire system. This makes the balancing of the load much less perfect than in cases where three-wire distribution has been rigorously enforced throughout all interior construction. On this account it is desirable to be able to throw both the 100-kw. rotaries on one side of the system at times or to be able to use the negative rotary on the positive side in case the positive machine is crippled, or vice versa.

It will be seen that by throwing the positive switch of one rotary, for example, upward and to the left, the positive brushes of the corresponding machine are connected to the positive main bus bar. The vertical position of the same switch leads to the positive auxiliary, while an upward position inclined to the right leads to the neutral. Downward to the left leads to the positive charging bus. In the same way the negative switch may be closed to the neutral, the negative main, the negative auxiliary, or the negative charging bus. In this way either rotary may be connected between the neutral and any one of the buses on either side of the system. The positive and negative switches of one rotary cannot be simultaneously closed upon the neutral, as these switch positions make the switch handles conflict with each other.

The fifth contact downward to the right on the positive switches only (the negative switches having only four directions) leads to the starting bus, which is connected through a rheostat switch—which appears on the sub-base of the left-hand panel of the switchboard—to the neutral bus bar. By closing the negative swivel switch of either rotary or any negative bus and the positive switch of the same rotary to the starting bus and by gradually cutting out the resistance by means of the rheostat switch, the rotary may be brought up to speed as a direct-current motor, taking current from the negative side of the three-wire system. It may then be synchronized, be thrown into circuit on the a. c. end and reconnected by means of its swivel switches between any desired bus bars on either the positive or negative side of the system. By means of the starting bus the one rheostat switch is made to serve for both rotaries.

Turning now to the large motor generator above referred to and illustrated in Fig. 3, its circuits are shown in the diagram of connections between the a. c. and the d. c. switches of the rotaries. The three-phase motor takes its power directly from the three 352-volt bus bars via switches, fuses, and one edgewise ammeter appearing on the second panel of the switchboard. As this set is always started from the direct-current end, having, on account of its commutators, rather too heavy a friction load for a. c. starting, there are no down or starting clips on the switches.

The rotary field of the synchronous motor is supplied through carbon brushes bearing on cast-iron collector rings. The field current is switched into or cut off from the machine by a special field switch which appears just below the edgewise ammeter on the motor panel of this machine, which is the second panel on the switchboard. This field switch, which is rather an interesting form, is illustrated in greater détail in Fig. 7. The two lower points or hinges of the switch are connected to the field winding, and the two upper points to the source of supply or bus bars. The contact with the upper clips is protected against arcing by secondary carbon breaks. Between the upper and lower clips are intermediate contacts of a novel form, such that when the switch is closed tightly into the upper contacts it clears the middle jaws but makes contact with them before opening from the upper contacts. Between these two middle contacts (see the diagram, Fig. 8) there is connected a non-inductive resistance. When the switch is wide open or closed, this non-inductive resistance is out of circuit, but as the switch is opened it throws this non-inductive resistance in parallel with the field before cutting the latter off from the source of supply. When the contact of the source of supply is finally opened at the carbon breaks, the inductive kick or discharge from the field finds a circuit through the non-inductive resistance, thus preventing serious arcing and the heavy strain on the insulation of the field winding which would exist were this arrangement not provided.

The same switch is used on all the synchronous motors throughout the station, all of which, with the exception of the one motor just described, are started from the a. c. end, and consequently no synchronizing lamps are used. In this case the same field switch is used to give a rough indication as to when the motor reaches synchronism. The motors are started, of course, with the field circuits open and with the main a. c. switches in the down or starting position, which cuts into the circuit reactive coils or compensators. When the motor reaches full speed and the revolving field set up by the polyphase currents in the armature winding locks into the poles of the field structure, the main a. c. switches should be thrown up to the running position and the field should be excited; but these should not be done before the motor reaches full speed, or throwing over the main switches will cause bad arcing, and the exciting of the field will cause heavy jumping of the alternating currents and blowing of the fuses. To determine whether the machine is up to speed, the knives of the field switch shown in Fig. 7 are touched up to the jaws connected with the non-inductive resistance. If the machine is below speed the rotating magnetism of the armature is travelling faster than the fields are travelling and is cutting the field windings and setting up therein an alternating e.m.f. This will give sparking between the knives of the field switch and the contacts of the non-inductive resistance, since the non-inductive resistance will short circuit the field windings and allow alternating currents to pass. If, however, the machine has reached speed and locked in step with the current supplied, there is no longer any alternating e.m.f. in the field winding and no spark can be drawn upon the field switch.

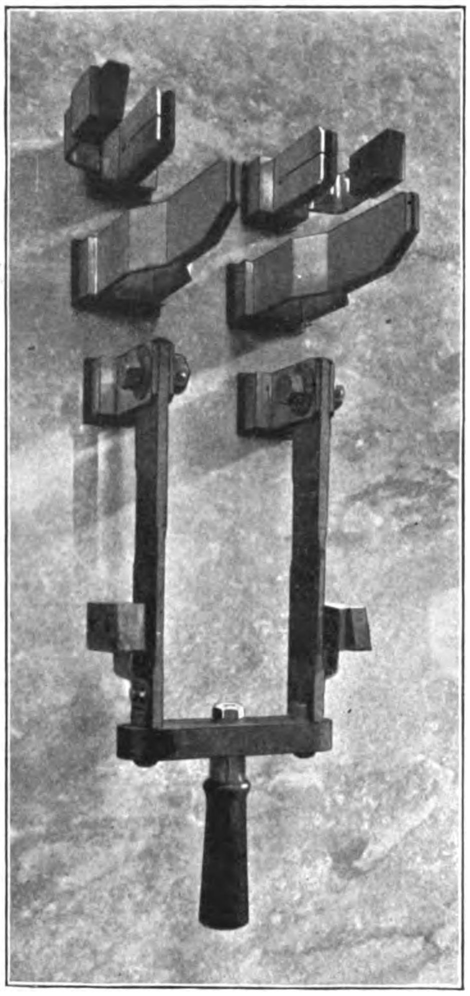


FIG. 7.—A FIELD SWITCH WITH SPECIAL CONNECTIONS FOR A NON-INDUCTIVE RESISTANCE.

To each side of the field switch on the second panel of the switchboard there may be seen a small knife switch, these two switches being used for synchronizing. The synchronizing arrangements are a little unusual in this case because it is desirable to determine not only whether the machine is in synchronism or not, but whether also the direction of the rotation of the alternating currents has been reversed. This is desirable to prevent any chance of trouble when the a. c. system may be shut down for a change of connections anywhere between Buffalo and Niagara. In this case it is possible that two legs of the circuit may be transposed, reversing the sequence of the phases and the direction of rotation of any motors running on the circuit. In this case the rotary converters and the alternating-current motor generators of the Buffalo General Electric Company would start up and run all right with no indication of the reversal if the attendant did not happen to glance at the machine at the instant of sarting, but the large motor generator started from the storage battery would be brought up to speed in the wrong direction with reference to the sequence of the phases, and as soon as the a. c. switches were closed would become a very complicated short circuit.

Fig. 9 is a diagram of the usual connection of synchronizing lamps across low-voltage machines where transformers are not used. In this case the lamps are in series with phase A B of the machine and the same phase of the source of supply in series with each other. As soon as these phases of the machine and bus bars, respectively, oppose each other at the same frequency, the lamps go out and the main switches may be closed. If, however, the machine is running in the opposite direction from that which it should be to lock in with the alternating currents, the lamps will go out just the same when the machine arrives at speed. Fig. 10 shows the arrangement adopted for the motor generator set described here. Leg C is closed at the main switch, throwing one set of lamps in series with phase A C of the machine and bus bars in series with each other and the other set of lamps in series with phase B C of the machine and bus bars in series with each other. The lamps used in this case get twice as high a voltage as in the other. If the machine is running in the right direction all lamps go out together as soon as it arrives at speed and at the proper phase relation for closing the switches. If, however, the machine is running in the wrong direction, one set of lamps will go out while the other remains burning, and the two cannot be made to go out simultaneously.

Beyond the panel for the direct-current ends of the motor generator there is mounted on the switchboard a handsome instrument panel. The main piece on this panel is a large Thomson three-wire integrating wattmeter which measures the whole power coming from the direct-current ends of the motor generator. The instrument is made with two recording trains similar to those used on General Electric two-rate wattmeters and a throw-over mechanism from one train to the other actuated by relays in such a way that when power is coming —as it normally should—from the a. c. system through the motor generator into the d. c. system, it is recorded on one train and dial, while if the direction of transmission of power reverses, going back from the storage batteries into the machine to generate a. c. currents, the meter mechanism is thrown over onto the other recording train and the reverse power is measured there. This brings up an interesting possibility of this big motor generator. In case the alternating-current input of the station fails, or it is desirable to shut it down for changes in the high-tension system, the motor generator will absorb power from the storage battery and give out alternating power from the windings of its synchronous machine. This alternating power can be used to drive other motors or rotaries in the station. If a short or shut down occurs on the alternating-current transmission line from the Falls, the motor generator will reverse and throw out the reverse-current circuit breakers in the alternating-current high-tension lines feeding the step-down transformer sub-station, which in turn supplies the central station of the Buffalo General Electric Company. These reverse-current breakers go out at 3000 amperes per phase on the 352-volt system.

When the source of supply was shut down for changes on the high-tension system the motor generator has been used to feed back from the storage battery and run one of the 250-light motor-driven arc sets, and one motor-driven alternator for the day load, as well as one of the 500-volt rotaries and one exciter set for exciting the synchronous motors.

Above the three-wire integrating wattmeter, on the instrument panel, appear two rotating brackets carrying double-decked pairs of Thomson astatic voltmeters. The upper pair are connected to a voltmeter switch by which both (one positive and one negative) can be thrown simultaneously to bus bars, battery or machines, while the lower pair are on positive and negative pilot wires brought back from a representative point on the Main Street mains for which it is desired to regulate the voltage.

The positive brushes of one direct-current machine of the motor-generator set and the negative of the other are connected through circuit breakers to one common neutral switch, as the diagram shows. These circuit breakers are mounted on the machines themselves, although they do not appear in the illustration, being on the opposite side from that photographed, and, by the way, circuit breakers are also mounted on the rotary converters, as the diagram also shows.

The outer brushes of the motor generator set are connected to the hinges or center contacts of a type of switch much used on this board (which will be here termed a double throw-over switch), each such switch consisting of two separate sets of blades, either of which can be thrown up or down, the hinges of both sets being mounted on one block, tying them electrically together. Throwing one of these sets of blades up connects the machine to the main bus, throwing the other up connects it to the auxiliary bus, while throwing either or both down connects the machine to the charging bus. The positive switch is thus connected to the positive main, auxiliary and charging buses, while the negative switch is correspondingly connected to the negative main, auxiliary and charging. Similar switches, similarly wired, are used for the storage battery and the outgoing feeders. Thus, for example, any feeder, any battery end-cell switch, or the motor generator may be connected to the main bus bar by half of its switch, to the auxiliary by the other half, or to the charging by both halves, giving twice as high conductivity in the last case.

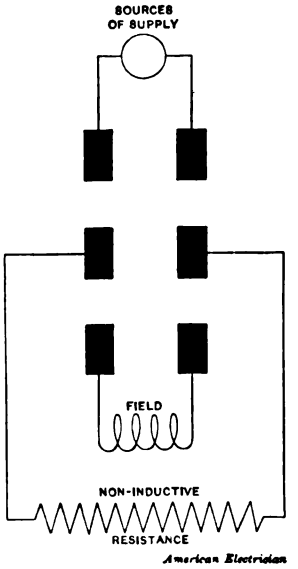
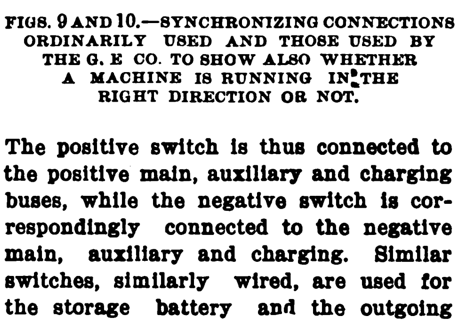


FIG. 8.—CIRCUITS OF SWITCH SHOWN ON OPPOSITE PAGE.



FIGS. 9 AND 10.—SYNCHRONIZING CONNECTIONS ORDINARILY USED AND THOSE USED BY THE G. E CO. TO SHOW ALSO WHETHER A MACHINE IS RUNNING IN THE RIGHT DIRECTION OR NOT.

To the right of the main generator switches in the diagram there will be seen what is termed a + or — starting switch, which is designed to start the motor-generator set, using either the positive or the negative direct-current dynamo of the set as the starting motor. By tracing out the connections it will be seen that when this double-throw + or — switch is thrown up it connects a rheostat switch between the positive main bus bar and the positive brushes of the positive machine. By closing the neutral switch, the positive machine is made a motor and the set is brought up to speed by means of the rheostat switch. If the + or — starting switch is thrown down the same rheostat switch is cut in between the negative main bus bar and the negative brushes of the negative machine, making that the starting motor.

The operation of this motor generator has proven so successful that the company has now decided to add another three-wire motor generator twice the size of that now in use. The direct-current generators of the future machine will be rated at 400 kw. each and driven by a 900-kw. motor.

THE STORAGE BATTERY.

The Buffalo General Electric Company contracts to take 3000 h.p. from the Niagara power system, but this is insufficient to carry the peak of its load in the evening, while more than sufficient for its day load. To make this amount of power carry the peak of the load as well as to steady the voltage on the three-wire system, the company has installed the large battery of chloride accumulators shown in Fig. 11. These consist of 150 cells, of which 38 are end cells, 19 for each polarity, with a rated capacity of 3000 amperes at a 1½-hour discharge rate. The batteries themselves are in the usual lead-lined tanks, mounted on porcelain insulators, and constructed and installed with the details which have become standard with the Electric Storage Battery Company. The currents are introduced to and withdrawn from this battery by means of the four motor-driven end-cell switches shown in Fig. 12. The two to one side of the door are for the negative end and the two to the other side of the door for the positive end of the battery, the heavy copper bar leading around and over the door being the neutral connection from the positive 75 batteries to the negative 75 batteries, this neutral connection containing two switches, shown in the illustration, and indicated in the diagram of connections, so that either half of the battery can be entirely cut off from the bus bars without throwing the other half out of circuit.

The storage battery is controlled by standard panels of the Electric Storage Battery Company mounted on the same switchboard shown in Fig. 4. As indicated in the general diagram of connections, each end-cell switch is connected to the bus bars by double throw-over switches similar to those described above in connection with the motor generator, one side of the throw-over switch going up to the main, the other side up to the auxiliary, and both sides down to the charging bus. These switches are mounted on the sub-bases of the battery panels, which appear in the illustration just beyond the instrument panel. The battery panels are also fitted with suitable ammeters and voltmeters and with end-cell indicators to show how many cells are in circuit. These are driven mechanically by rods and bevel gears from the end-cell switches which are in another room. The panels carry small five-volt round-type Weston voltmeters and voltmeter switches by which the voltmeters can be connected onto any one of the end cells to determine when it needs recharging.

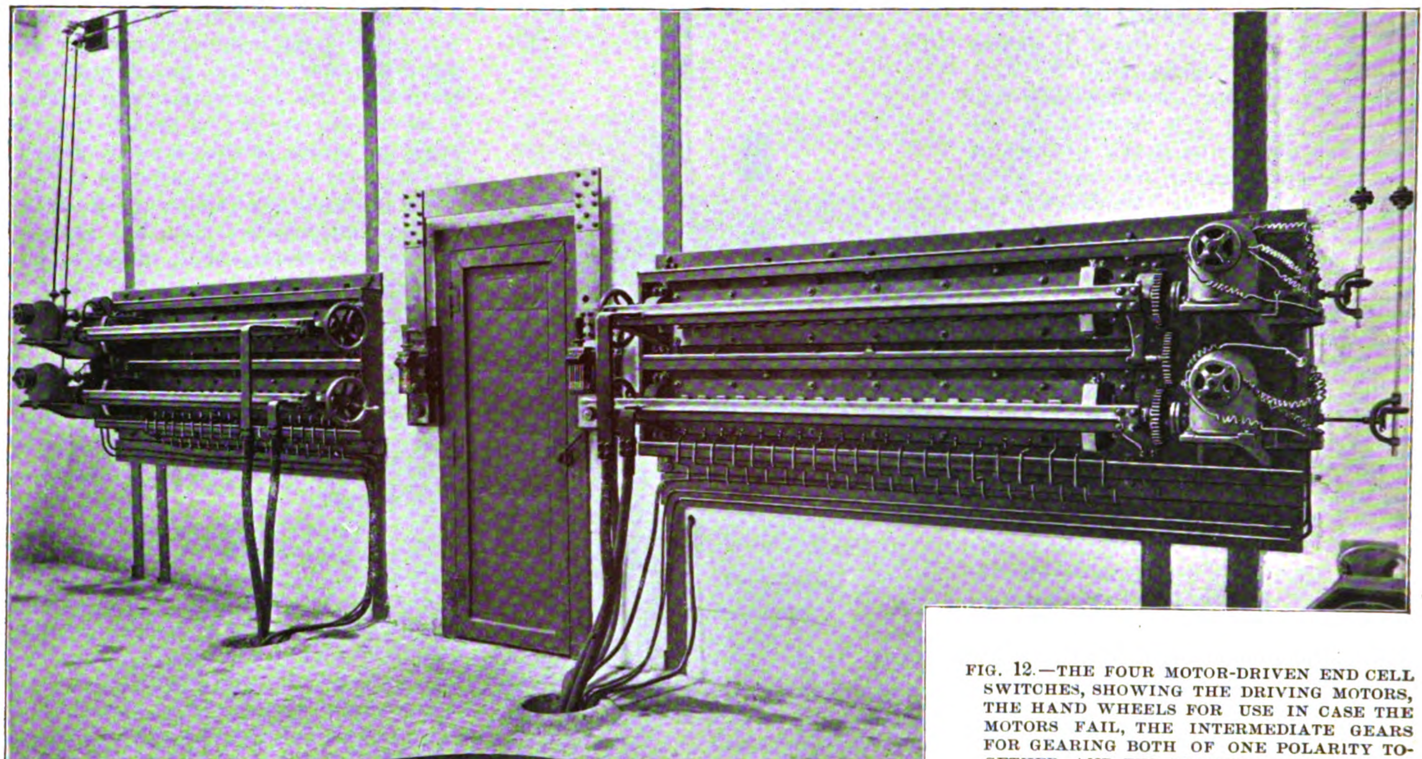


FIG. 12.—THE FOUR MOTOR-DRIVEN END CELL SWITCHES, SHOWING THE DRIVING MOTORS, THE HAND WHEELS FOR USE IN CASE THE MOTORS FAIL, THE INTERMEDIATE GEARS FOR GEARING BOTH OF ONE POLARITY TOGETHER, AND THE BEGINNING OF THE MECHANICAL TRAIN TO THE INDICATORS ON THE SWITCHBOARD.

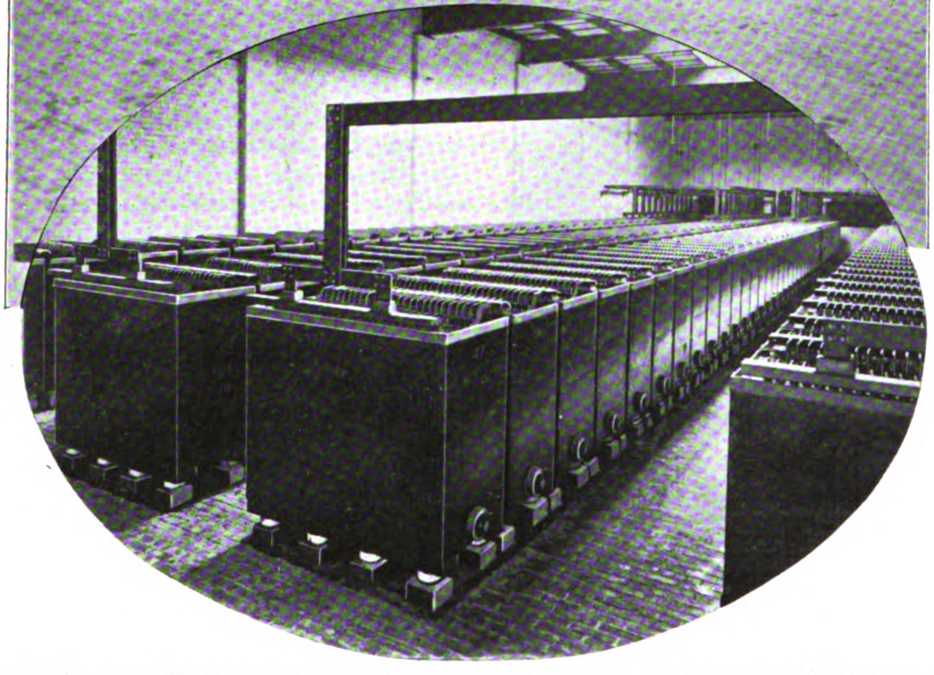


FIG. 11.—THE 150-CELL THREE-WIRE STORAGE BATTERY, WITH A CAPACITY OF 3000 AMPERES FOR 1½ HOURS. IN THE BACKGROUND ARE 38 END-CELLS, 19 FOR EACH POLARITY.

The outgoing feeders from the station are also taken off from the bus bars through throw-over switches similar to those described above, by which they can be connected to main, auxiliary, or so-called charging buses. These switches for the four feeders now in use are on the end panels of the board most distant in the illustration, and these feeder panels also carry two ammeters, one for the positive and the other for the negative side of the system. These ammeters are connected through an ammeter switch to shunts in the feeders, such that the one pair of instruments can be thrown from shunt to shunt to measure the output in any of the feeders. The ammeter switch, as well as the voltmeter switch mentioned above, is double-pole, i. e., by rotating one switch handle both ammeters are thrown at the same time from shunts in the positive and negative lines of one feeder to those in another.

As noted above, the company contracts to take 3000 h.p. from the Cataract Power & Conduit Company. The peak of the load requires almost 4000 h.p., about 500 of which is readily obtainable from the battery. The peak of the demand made by the Buffalo General Electric Company upon the Cataract Power & Conduit Company amounts to about 3400 h.p. The demand throughout the 24 hours averages about 2200 h.p. The battery is made to carry the three-wire incandescent load during the evening without any help from the machines, the motor generator and the rotaries being shut down so as to reduce the load peak. During the day, when the arc and incandescent load is very light, the motor generator is run to carry the 220-volt load and charge the battery. As soon as the battery is charged the motor generator is shut down and the rotaries are started up to carry the three-wire load, the battery charge being retained for the evening peak.

The station is laid out to reduce the cost of necessary attendance to a remarkably low figure considering the amount of machinery it contains. Two men on the night shift attend to all the apparatus in the station, which consists roughly of the following:

Fourteen 150-kw. motors, driving twenty-eight 125-light arc machines.

Two 425-kw. motors, driving 62½-cycle alternating-current generators.

One 425-kw. motor, driving direct-current generators.

Two 200-kw. and two 100-kw. rotaries, and two 30-h.p. exciting sets.

In addition there is required one man in the adjoining step-down transformer substation.

The station runs with a remarkably high efficiency considering the multiplicity of the machines. The direct-current output is regularly every day compared with the alternating-current input, as may be seen by a fac simile of the daily report

BUFFALO GENERAL ELECTRIC CO.

—o—

Daily report of station..........

For 24 hours ending 7 A. M......

STATION OUTPUT IN KILOWATT HOURS, AT SWITCHBOARDS.

Arc system, ... kw. h.
60 cycle system, ... " "
Edison system, ... " "
550 volt d. c. system, ... " "
Total output, ... " "

Total input from C. P. & C. Co., ... kw. h.
Maximum power received, ... h. p.
Minimum power received, ... " "
All day efficiency of plant, ...per cent.
Input in storage battery, ... kw. h.
Output from storage battery, ... " "
Maximum power from battery, ... h. p.

Operating cost per kw. h., of output.......... cents.

blank, as given above. The all-day efficiency is figured every day and amounts, on the average, to about 80 per cent. between the 325-volt 25-cycle input and the d.c. and 62½-cycle a.c. output of various kinds. The efficiency of the arc sets from switchboard to switchboard figures up 80 per cent., 600 watts of alternating current being required per 2000-c.p. arc lamp burning in the street, including all line losses, showing an efficiency of 75 per cent. from 25-cycle bus bars to lamp in the street.

The effective and satisfactory service, efficient operation and ingenious solutions of the many novel alternating-current problems which arose in laying out this station, are creditable to the engineering staff of the General Electric Company, which built all the apparatus, and to Mr. H. G. Stott, the Electrical Superintendent of the Buffalo General Electric Company, who has had immediate charge of the entire work. To the latter are also due thanks for the whole of the information given above, as well as much more that could hardly be given here owing to its technical character and lack of space in these columns.

The Electrical Equipment of the Printing Establishment of the "St. Louis Republic."

BY GEO A. DAMON.

There are few places in which the electrical operation of the equipment will show more advantages than in a printing establishment, and this is especially true if the plant is a new one. In this connection the experience of the "St. Louis Republic" is of interest. At the time this paper decided to build its present beautiful and commodious home, the electrical driving of printing presses was a demonstrated success. Plenty of room was left, however, for improvement over existing methods of speed control, and the application of motors to the auxiliary machinery had not been so thoroughly worked out. Moreover, the question of whether or not to install an isolated generating plant had to be carefully considered from all the standpoints of first cost, economy in operation and reliability. The conclusions reached and the results obtained are worthy of description.

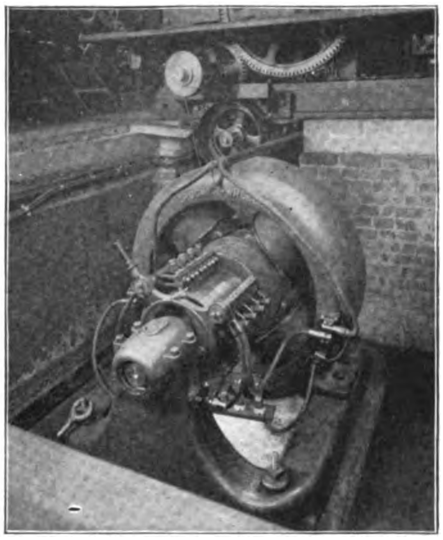


FIG. 1.—PRESS-DRIVING MOTOR IN BRICK PIT.

To decide whether or not to put in a generating plant a load diagram was plotted which showed the extent and peculiarities of the estimated demand for electrical energy for both lights and power. The "Republic" is a morning paper, and, therefore, this preliminary study of the conditions showed that the bulk of the power used would be between the hours of 5 o'clock in the afternoon and 5 o'clock in the morning, the peak of the load coming during the two hours following midnight. Very little power is used during the day. It will readily be seen, therefore, that this load is a very desirable one for any central station, and the resulting low bids received from the competitors for this business showed that an isolated generating plant would not be a good investment.

Power is taken from the mains of the Imperial Company. This central station (which was described in our December issue) distributes a direct current over a three-wire system having a potential of 470 volts across its outside wires with a grounded neutral. The current passes into the building through a switchboard, provided with a separate switch for each of the nine circuits which supply the different classes of service. From the switchboard each circuit on its way to its respective part of the building passes through two Thomson wattmeters in series—one wattmeter for the supply company and the other for the "Republic"—each acting as a check upon the other. These nine separately measured circuits control the electrical energy used for lighting the halls, the third floor, the basement, and the counting room, and the power furnished to the passenger elevators, the freight elevators, the linotype machines, the stereotype department and the presses. The separate wattmeters furnish a ready means of checking the cost of power used by each department, and of suggesting economical measures. The only steam equipment about the building is a boiler used for heating purposes attended by the janitor.

In connection with the motor equipment the application and the speed control of the press motors was the most serious problem. The printing of the "Republic" requires three Hoe quadruple presses, each capable of printing 24,000 papers per hour. The main driving shaft of such a press turns 200 times a minute when the press is running at its highest speed, and thus 200 r.p.m. would be the maximum speed of a motor directly connected to the press shaft. This slow speed would result in a large motor and its application directly to the shaft would locate it in an inconvenient place. The motor was, therefore, geared to the shaft so as to bring the maximum motor speed up to 700 r.p.m. and by means of a train of gears it became possible to place the motor beneath the floor at the side of the press. The four-pole motor is illustrated in Fig. 1, which indicates the construction adopted, and shows the steel-lined brick pit provided to secure a water-tight compartment for it. The press-room floor is composed of cement except over the motor pits, which are spanned by hard-wood planks—a construction which, together with the roomy pits, secures easy access to the motor and connections. A small man-hole is placed at one side of the pit and is used for the ordinary purposes of oiling and inspection.

The method of speed control adopted is the combination of armature resistance, field regulation, and the "teaser" system, as developed by the Crocker-Wheeler

Company, the builder of the motors and auxiliary apparatus used. In operating newspaper presses it is essential to provide five or six very slow speeds to be used in adjusting the presses, and in threading through the paper while "making ready" to run an edition. In doing this work the press attendants become familiar with certain speeds, and any variation not only hinders them in their work, but is also liable to prove dangerous to the hands which are trained to certain motions. These slow speeds must, therefore, be constant.

The limitations to the use of armature resistance for securing a reliable slow speed from a motor working on a variable load are well known, and its use was not considered in connection with this plant. The very slow speeds are secured by the use of a "teaser" which is a small motor dynamo running at a constant speed. The motor end of this teaser takes its current directly from the 470-volt mains while the generator end delivers current to the press motor at a potential varying between zero and 80 volts, which gives a range of very low constant speeds. Higher speeds are obtained by throwing the press motor upon the 470-volt mains through resistance and normal full speed is attained when this resistance is cut out. Speeds above normal are obtained by slightly weakening the field strength of the press motor itself.

The various combinations and the resulting speeds are secured by the manipulation of a controller (shown in Fig. 2) located at the side of the press. This device looks very much like a street-car controller, and is provided with a hand wheel fitted with a pointer which moves over a dial containing 21 points in the polished brass top.

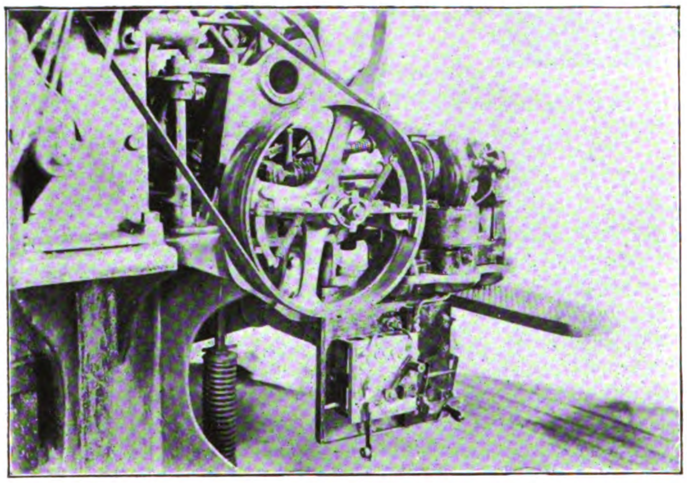


FIG. 3.—MOTOR CONNECTED TO LINOTYPE MACHINE.

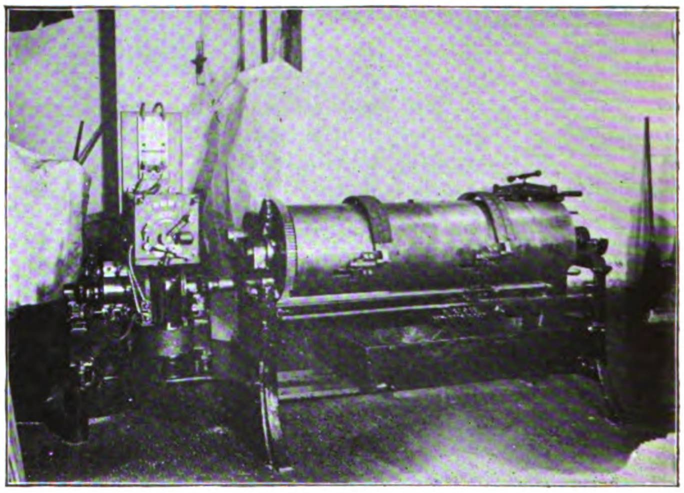


FIG. 4.—MOTOR-DRIVEN TAIL CUTTER.

The operation of the system is as follows: The controller is placed on the first point, which admits current to the press motor from the teaser generator, and results in the lowest running speed. The speed is increased by moving the controller from point to point—a ratchet and spring device preventing the stopping of the controller handle between points. Passing to points two and three cuts out resistance in the teaser generator field and raises its voltage. Points four to six cut out armature resistance in series with the teaser, and thus six different slow speeds are secured by means of the teaser. When the controller handle passes from point six to point seven the teaser is cut off from the press motor, and the motor begins to get its current from the main line through resistance. Points seven, eight, nine and ten are running points, using armature resistance in the motor circuit, the resulting number of impressions being from eight to twenty thousand per hour. When the controllers reach point eleven all the armature resistance is taken out of the circuit, and the motor is running most efficiently with its strongest field, and the press is printing about 22,000 papers per hour. The higher points on the controller introduce resistance into the field circuit thus weakening the field and speeding up the motor. These higher speeds are seldom used.

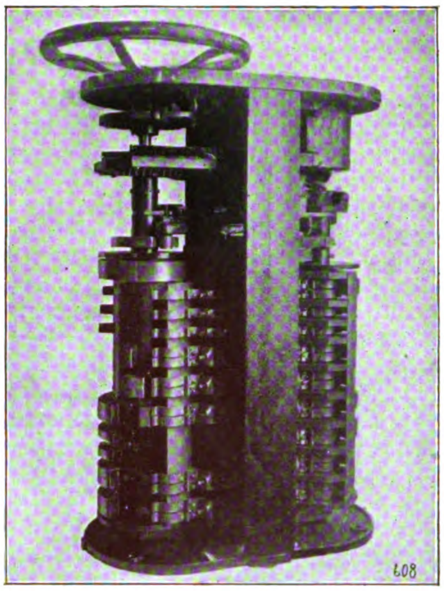


FIG. 2.—THE CONTROLLER OF A PRESS MOTOR FOR COMBINED RHEOSTATIC AND TEASER CONTROL.

The controller is provided with a solenoid magnet circuit breaker which opens the circuit automatically in case the line voltage fails. This circuit breaker can also be operated from any one of six push buttons distributed at convenient points about the press frame. A band brake, actuated by means of a spring and controlled by a solenoid magnet in series with the main circuit is provided, which applies itself instantaneously to gradually stop the press in case the line circuit fails or any one of the stop buttons is pushed in an emergency.

The size of the motor on each press is 40 h.p., though the actual power required at present is less than 30 h.p., the extra capacity having been provided for driving another "deck" to be added to the press in the future. The leads to each motor are controlled by a switch on the press, and are also protected, in addition to the automatic devices on the press controller, by means of an I. T. E. overload circuit breaker placed on the press frame, convenient to the operator. A carbon resistance is connected across the terminals of auxiliary clips on the main line switch in such a way as to take up the field discharges when the main line is opened. The armature and field resistances are mounted on a frame placed beneath the press, and both are arranged in sections so that their subdivisions can be changed and any desired arrangement of speeds can thus be secured. All the wiring between the motor, the controller and the push buttons is done in iron-armored conduit.

Before the modern newspaper reaches the press, however, it has passed through a number of interesting processes, in all of which electricity is now playing a part. In the "Republic" composing room there stands an old hand proof press similar to the ones used in the time of Franklin, which furnishes a striking contrast to the modern newspaper making machinery with which it is surrounded. The reading columns of the newspaper of to-day are set up on linotype or type-setting machines, those in use by the "Republic" being of the Mergenthaler type. There are twenty of these machines, each being operated by an individual ¼-h.p. motor driving its main shaft by means of a worm gear. These motors are shown in Fig. 3.

While the compositors are busy with the reading matter the art department is making the line and half-tone cuts, using powerful arc lamps in the necessary photographic processes. This department also uses a ½-h.p. motor to operate the rocking device of the acid bath; a ½-h.p. motor belted to the router, and a 2½-h.p. motor belted to the saw and trimmer. The composing room and the stereotype room are also equipped with a belt-driven saw and trimmer similar to the one in the art department.

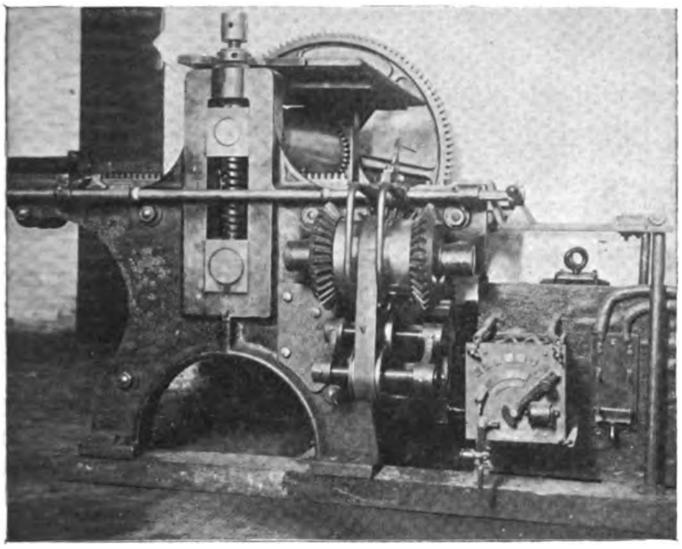


FIG. 5.—MATRIX ROLLING MACHINE.

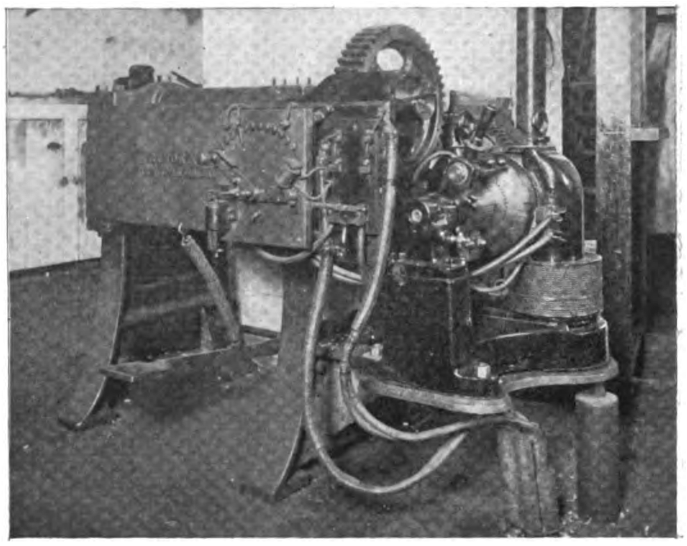


FIG. 6.—SHAVING MACHINE.

When the cuts and type are finally made up into forms these are sent to the stereotype department. Here a mould from paper pulp is first made on the matrix rolling machine (Fig. 5). As this machine travels forward the type form passes under a roller which presses down on the type the soft paper pulp sheet, and at the end of its travel the machine automatically reverses, passing the table back again under the roller. These movements are ordinarily accomplished by a belt-shifting device which pushes the belt from an idle pulley in the center upon driving pulleys directly attached to bevel gear wheels upon either side of the main shaft. The difficulty in electrically operating this machine is to get the motor under the machine out of the way of the operator and at the same time retain the automatic reversing device. A reversing motor might have been installed, either geared or direct connected to this machine, but the stopping and starting again of this motor would necessarily take some time, and every second is of importance when a newspaper reaches this period of its making. In this case the result was accomplished by providing the motor with a long pulley and an outboard bearing. From this pulley the belt passes to the driving pulleys under two idler pulleys, which are carried on a special bracket, and can move along their shafts when the belt is shifted. The arrangement works very successfully. The motor is a 2½-h.p. compound-wound machine running at 450 r.p.m.

The curved stereotype plates are then cast in the mould which bears the imprint of the type. These plates are next strapped on the tail-cutter and the excess metal is removed. This machine (Fig. 4) is driven by a 4-h.p compound-wound motor supported on an extension bracket and attached directly to the saw shaft, which runs at 1400 r.p.m.

The plates are then placed in the curved shaver, which shapes their interior surface. This shaving machine is operated by a 4-h.p. compound-wound motor running at 900 r.p.m. and geared by a rawhide pinion gear to the driving shaft (Fig. 6). It is necessary to have the shaving knife make one revolution and then stop in a position which will allow the insertion of the next plate. This is accomplished by a push button device which short circuits the magnet on the automatic starting box, thus stopping the motor. This push button is operated by a rod working on a pin attached eccentrically on the end of the shaft. Three 1-h.p. motors are used on the carriers which transfer the papers from the presses to the distributing room. These motors are geared to a drum driving an endless cable and are reversible—the starting box being arranged so that it can be controlled from either end of the carrier.

Additional motors are used in this plant to operate one freight elevator, two passenger elevators, one form elevator, one paper lift and a pneumatic blower for supplying air to the tube system. The blower uses a centrifugal fan run by a 5-h.p. shunt-wound belted motor, with an armature resistance speed controller.

The building is lighted by 235-volt incandescent lamps and enclosed arc lamps run two in series across the 235-volt mains. These lights are controlled from centers consisting of marble switch panels in cabinets with glass fronts. The 220-volt arc lamps were found to be unsatisfactory for interior lighting on account of the preponderance of violet rays.

The advantages of electrical operation are well demonstrated in this plant. In arranging the equipment, the placing of the separate machines was not determined by the location of a line shaft, and full advantage was taken of this fact. In planning the stereotype room, for instance, the machines were not placed at right angles, as is usually the case, but were set in positions which would reduce the number of steps and motions of the workmen to a minimum. The architect, in planning a fireproof building, was not handicapped by the necessity of providing shaft pits or belt ducts, with the consequent dangerous opening through walls and floors. The evenness of the power from the press motors, the wide range of available speeds, and the convenient method of control, are important benefits in newspaper printing. The cleanliness, reliability and economy of electric transmission have often been pointed out, and it only remains to be said that the results obtained in the "Republic" plant add evidence of these advantages.

The successful completion and operation of a plant of this kind is always the result of the painstaking care of a certain number of men. In this case those who should be given their share of credit are Chas. W. Knapp, President and General Manager; W. B. Carr, Business Manager of the "Republic"; Isaac Taylor, Architect; and Bion J. Arnold of Chicago, Consulting Electrical Engineer. The entire motor equipment, except for the elevators, was furnished and installed by the Crocker-Wheeler Company. The wiring of the building was done under the direction of George J. Percival.

THE METROPOLITAN RAILWAY COMPANY, TORONTO, ONTARIO, AND ITS DOUBLE-CURRENT SYSTEM.

A new power plant has been constructed by the Metropolitan Railway Company, Toronto, Ontario, and the length of the railroad has been more than doubled. The track previously extended from Yonge Street, North Toronto, to Richmond Hill, a distance of 14 miles, with the power station at Deer Park. The tracks have now been opened from Richmond Hill to New Market, 30 miles from Toronto. The old power station has been entirely abolished and a new one constructed at Bond Lake, 18 miles from North Toronto and 12 miles from New Market, the present terminus of the line. There is also a sub-station, with rotary converters and transformers, at York Mills, 4½ miles from North Toronto.

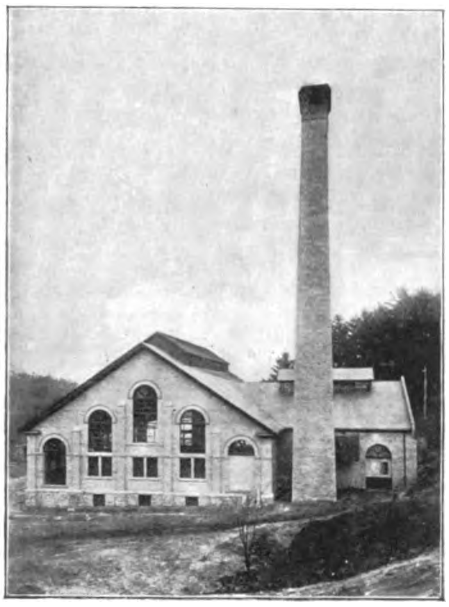


FIG. 1.—EXTERIOR OF POWER HOUSE AT BOND LAKE.

The railroad connects at North Toronto with all the tramway lines of the City of Toronto, and takes a northerly course in a straight line through the villages of Lansing, Glen Grove, Newton's Brook, Thornhill, Richmond Hill, and Elgin Mills to New Market. The track is laid in a very substantial manner with 70-pound "T" rail, bonded, having the regular railway gauge of 4 feet, 8½ inches, as it is intended to connect with the Canadian Pacific Railroad at North Toronto for the interchange of traffic. A Baldwin-Westinghouse electric locomotive, which will be described later on, will haul freight cars from the Canadian Pacific Railroad to and from all stations on the Metropolitan Railway Company's system. At present the district through which this railway passes is served by the Grand Trunk Railway only. The railroad ascends gradually from North Toronto for a distance of 22 miles to the summit of the divide or water shed which is between Aurora and Bond Lake, reaching a height of 1,400 feet above the level of the lake. From this point there is a gradual descent to New Market. The line follows a comparatively straight course, but there are several long grades, the steepest of which is eight per cent.

The contract for the building of the new power plant and the additions to the line was granted to the Imperial Lumber Company, Limited, Toronto, who employed the Westinghouse Electric & Manufacturing Company to supply the electrical plant and railway equipment. This contract comprised a new generating station and sub-station equipment, also motors for freight and passenger rolling stock and an electric locomotive.

The new power house, an exterior view of which is shown in Fig. 1, is at Bond Lake, 18 miles from North Toronto. The power house has been erected by the side of the lake, from which water for the boilers and condensers is readily obtained. The building is of brick with steel truss roof. One end of the building serves for the boiler house, the smoke stack abutting upon the western wall. Adjoining the boiler house and extending 10 feet beyond it on either side, is the engine and dynamo room, containing two cross-compound condensing steam engines, belted to two 275-kw. Westinghouse double-current 60-cycle, three-phase generators running at 600 r.p.m., wound for 400 volts alternating current, and for 570 volts direct current. An interior view of the power station is shown in Fig. 2.

The direct current supplies the local feeders, the alternating current being carried to the transformers and transmitted to the rotary converters in the sub-station at York Mills. The generators are designed to deliver and utilize their full rated capacity at the direct-current end or at the alternating current end, or the loads may be divided in any proportion between the two ends, as may be called for by the varying loads passing over the railway. Whether the demand be from local points near the power house requiring ordinary direct current delivered to the trolley line, or an extra demand arises for the high voltage alternating current to the sub-station line, the generators will deliver automatically what is demanded up to their full rated capacity.

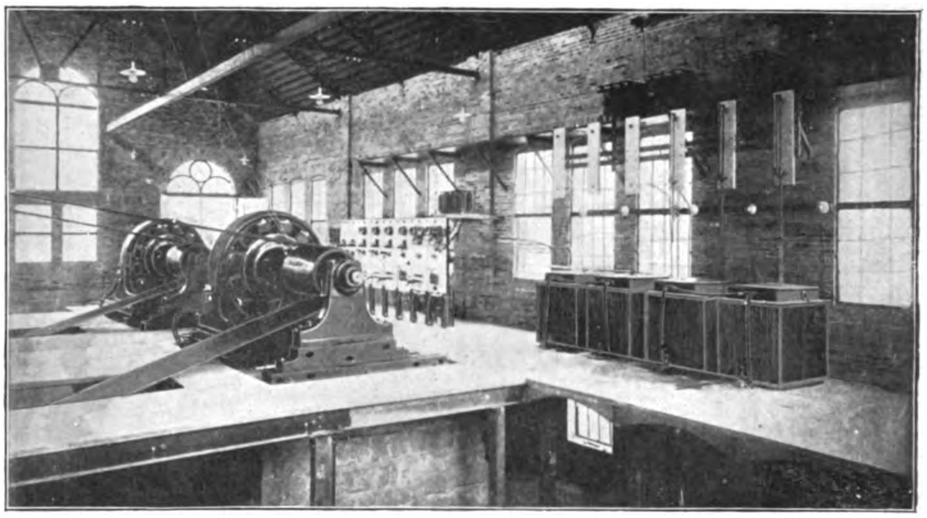


FIG. 2.—INTERIOR OF POWER HOUSE AT BOND LAKE, SHOWING BELT-DRIVEN DOUBLE-CURRENT GENERATORS, SWITCHBOARD AND TRANSFORMERS.

The generators are guaranteed to have an overload capacity of 15 per cent. for twenty-four hours with a rise in temperature not to exceed 50 degrees C. above the surrounding air, and to carry 40 per cent. overload for two hours, or 50 per cent. overload for one-half hour without injurious heating and sparking.

Two exciters of the standard Westinghouse type have been belted to the ends of the generator armature shafts; they are of the four-pole type, compound wound, 125 volts, operating at 1,600 r.p.m. The alternating current from the generators is carried to four 125-kw. Westinghouse transformers of the self-cooling oil-insulated type, which are placed near the end wall of the power house. They are wound for 400 volts primary and 15,000 volts secondary, two of them being connected with each generator. The high-tension current is conveyed by overhead lines to the sub-station at York Mills.

The marble switchboard consists of eight panels, and occupies the end of the power house. The switchboard is arranged for the paralleling of the alternating current ends of the two generators, and also for the paralleling of the direct current ends of the two double-current generators, together with the two generators formerly used in the discarded power house of the company, which are to be rewound for present service.

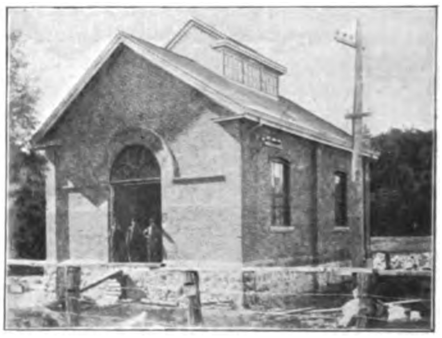


FIG 3.—ROTARY SUB-STATION AT YORK MILLS, METROPOLITAN RAILWAY CO., TORONTO.

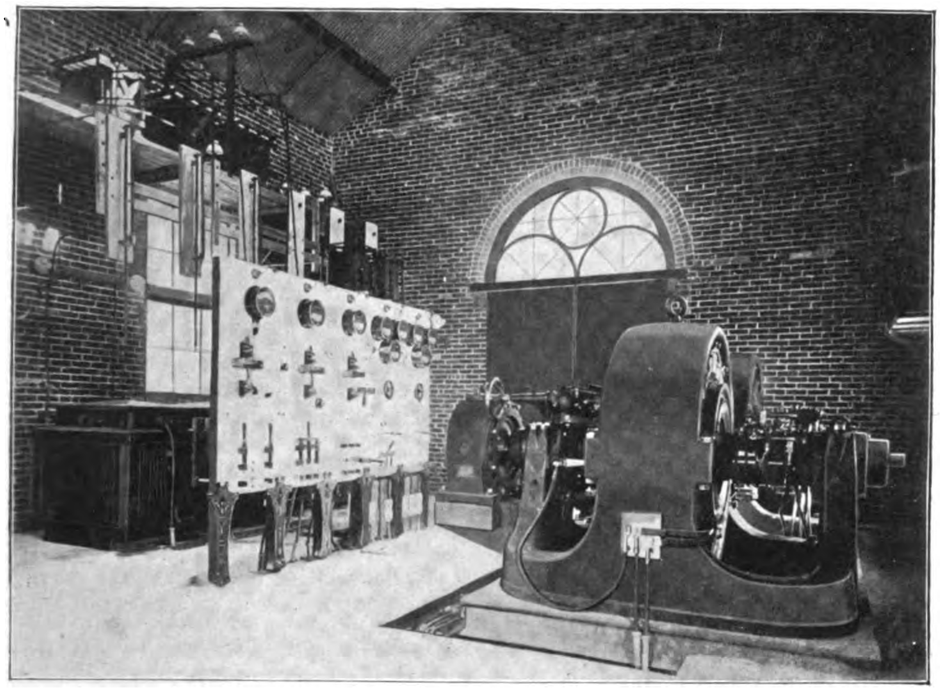


FIG. 4.—SUB-STATION AT YORK MILLS, SHOWING ROTARIES.

The equipment of the sub-station at York Mills, an exterior view of which is shown in Fig. 3, consists of four 100-kw. transformers similar to those in the power house, wound for 15,000 volts primary and 400 volts secondary, two for use with each rotary. The current is carried from the transformers to two 200-kw. rotary converters seen in Fig. 4, which transform the 60-cycle, three-phase, alternating current into a 570-volt direct current for local distribution. The rotary converters and the transformers are designed to carry an overload of 25 per cent for twenty-four hours without a rise of more than 60° C., and to carry a 50 per cent overload for two hours, without injurious heating or sparking.

It is proposed to make further extensions to the Metropolitan Railway Company's lines; one 13 miles in length is already under construction, extending from Aurora westward. The plans of the company anticipate a time when a large central power station will be necessary, and the present generators will then serve for rotary converters. This can be effected by removing the pulley and placing in its stead a starting motor, or bringing them up to speed by any other extraneous means, or as direct-current motors. The generators are equally serviceable for the supply of energy for incandescent or arc lighting, and for power for polyphase induction or synchronous motors. The rotary converters at present are started by induction motors, placed on the shafts of the rotaries and supported on brackets. Upon the proper speed being reached as indicated by the synchronizer on the switchboard, the rotary's switch is thrown in and the machine maintains its own speed, the starting motor being then out of circuit.

The generators at the central station and the rotary converters at the sub-station operate in parallel at both ends, and the generators are arranged to operate in multiple with the older direct-current machines previously used on the railway company's line when the latter shall be compound wound.

Ample protection against electrical storms has been provided by equipping the station with three Wurts lightning arrester outfits for 15,000 volts for the alternating current line and a Wurts railway tank lightning arrester outfit for the direct-current side. A good ground for the lightning arresters has been provided by a plate of No. 16 tinned copper, placed in a pond, which is connected by an almost straight wire with the arresters. One individual arrester has been connected with each direct-current panel of the switchboard.

The Metropolitan Railway Company has added to its rolling stock some freight cars, some of them of a heavier kind, equipped with four 38-B Westinghouse motors, also smaller ones with a double 49 Westinghouse equipment. They have also added single-truck passenger cars, and some 45-foot double-truck passenger cars with four-motor equipments.

The Metropolitan Railway Company is building up a considerable freight and express business, which it intends to increase in the near future and for this purpose has provided the electrically propelled freight cars mentioned above, which are engaged in carrying milk and farm produce to the City of Toronto, and general merchandise to the villages upon the road. The coal used at the central generating station has hitherto been trans-shipped at North Toronto into smaller cars, and hauled to the generating station by the trolley cars. The Metropolitan Railway Company has now added to its rolling stock a Baldwin-Westinghouse electric locomotive, which in the future will haul railway cars direct from the lines of the Canadian Pacific to all stations upon the system. By this means the cost of trans-shipment will be avoided, and farmers will be able to load their produce upon railway cars and have it conveyed without trans-shipment to any point in the United States. The Baldwin-Westinghouse electric locomotive shown in Fig. 7, has driving wheels 33 inches in diameter, and weighs 57,000 pounds. It is equipped with four 38-B motors similar to those already mentioned. A complete air brake equipment has been provided for the locomotive, including a combined pump and motor, with capacity for five cars; and in addition an efficient hand brake to all wheels. The locomotive is designed to run at a speed upon the level of 35 miles an hour, hauling cars with an aggregate weight of 60 tons.

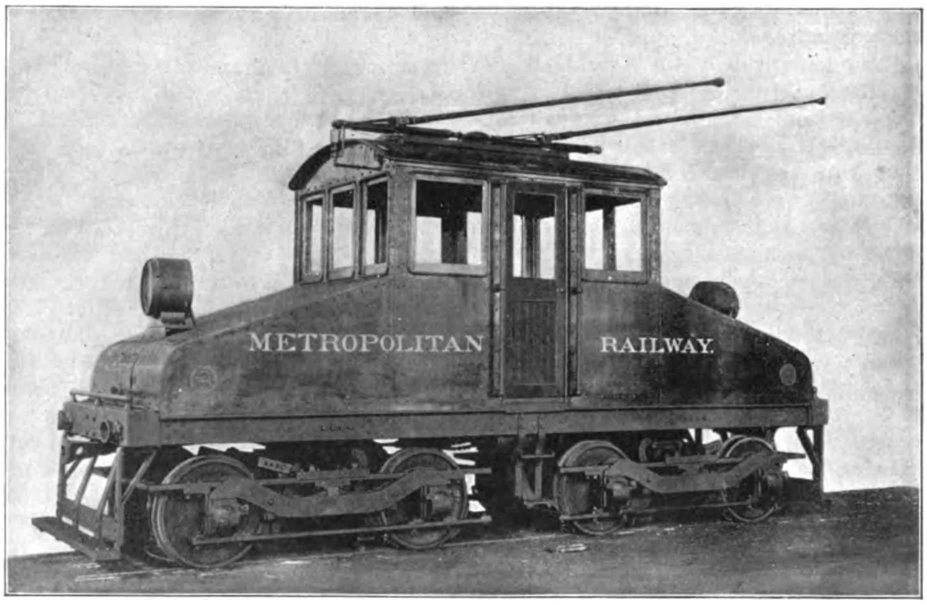


FIG. 7.—BALDWIN-WESTINGHOUSE ELECTRIC LOCOMOTIVE, WEIGHING 57,000 LBS.

Cure of Electrolysis by Independent Returns.

BY C. A. NEWBAKER.

The study of electrolysis from a scientific standpoint includes investigations of the chemical combinations of metals and electrolytes. In the cure of the electrolysis of underground piping the chemical side of the question is rarely considered. Electrolysis as a chemical action is set up by the flow of current from the pipes or cable sheaths being electrolized, and it has proven more easy to remove the electrical currents than to attack the problem from the chemical side.

If it were an easy matter to place a line of lead-sheathed cable or iron piping in an element in which the combination of atoms and molecules necessary for electrolysis did not exist, the problem would be as satisfactorily solved, but the ordinances of our large cities require the wires and pipes of the large companies to be placed underground. In the case of telegraph and telephone companies these wires must be protected absolutely from moisture. This requires covering the wires with some impervious substance, and for ease of manufacture and general suitability, no substance seems to suffice so well for this purpose as lead. Unfortunately, lead has a high electro-chemical equivalent, that is, a large amount of it is dissolved per ampere hour of current flowing from it, and unfavorable earth conditions cause its rapid decomposition. Further, the streets of large cities are particularly favorable to electrolytic action on lines of metal laid under them, as the ground contains years of accumulation of impurities which form acids and alkalies for electrolytes.

For reasons given above, we shall confine ourselves in this article to a discussion of the electrical conditions that cause dangerous electrolysis, and the best (which means the simplest, most effective and most economical) means to alter favorably these conditions.

The currents that cause electrolysis are invariably due to street railway systems using a track return. The fall of potential in this track return between distant ends of the line and the power house causes part of the current to leave the rails or the special return wires provided for it and distribute itself in the surrounding ground, seeking the paths of least resistance back to the power house. These paths frequently consist of water or gas pipes or the lead sheaths of underground electrical cables.

All traction systems nowadays work with the positive pole of the dynamos to the line and the negative pole to the ground. (See Fig. 1.) Thus the electrical current flows out from the power house over the trolley wires and back to the power house in the grounded return. On this account any current that strays from the ground return leaks into any underground pipes or cable sheaths at points distant from the power house and leaves them again at points near the power house, where the current tends to find its way back to the rails or other parts of the return circuit in order to reach the negative bus bar.

A fortunate peculiarity of electrolytic action is that no metal is dissolved where the current flows into a pipe from the surrounding ground, but all metal is dissolved by the current leaving the pipe and flowing into the material surrounding it. On account of this and the fact that the positive pole of the dynamos is to line, the tendency is to localize all the trouble in a small district near the power house. If a trolley line were worked with the negative pole of the dynamos to line and the positive to ground, the direction of the flow of current would be in the opposite direction; the current would flow into the pipes near the power house and out from them at widely distributed and distant points, thus spreading the trouble over large districts, where its remedy, as pointed out below, would be difficult. If any traction line is so worked and there is any danger of electrolysis, its polarity should be immediately reversed.

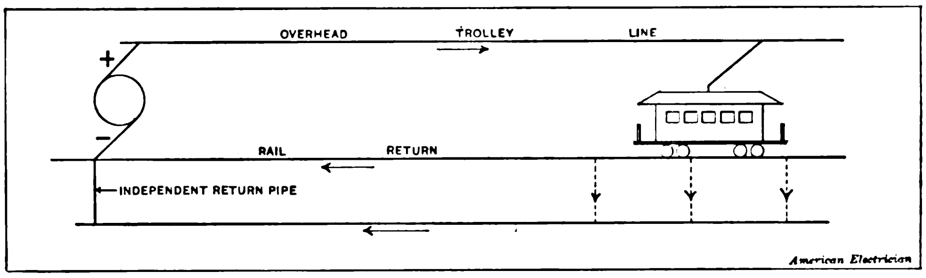


FIG. 1.—DIAGRAM SHOWING DIRECTION OF FLOW OF CURRENT THROUGH A TRACTION SYSTEM.

The independent return method of curing electrolysis, which has now been generally adopted through this country, consists of running metallic connections from all underground piping, cable sheathing, etc., to the return circuit of the traction system or its negative bus at all points where the current tends to leave the piping and return to the traction circuit. These metallic connections act as a low resistance shunt to the path through the ground from the pipe to the rails, so that the current tends to pass via the metal instead of through the ground. The current leaving the pipes via the metal path of course does no harm and, as noted above, the current entering the pipes also does no harm, so that the method where thoroughly carried out is a highly satisfactory one. Care should be taken not to connect the pipes to the rails at points where the current tends to flow from rail to pipe, since if this is done it will only introduce more current to the pipes, which current will have to leave the pipes at some other location, and is likely to leave them through the ground and set up electrolysis. The pipes should, therefore, be as thoroughly as possible insulated from all connection with the rail return circuit at points where current tends to flow from rail to pipes, but at points where the current tends to flow from pipes to rail the tendency should be helped by low-resistance metallic conductors.

Since the circuit between the pipes and ground cannot be broken for the insertion of ammeters, the whole tendency of the current to flow into or out from the pipes is determined by means of low-scale voltmeters connected between the pipes and the ground in their immediate vicinity. Where the voltmeter gives a reading showing that the ground is electro-positive to the pipe; i. e., that there is a fall of potential between the ground and the pipe, the latter is known to be safe, as any flow of current would be from the ground into the pipe, and would not cause any electrolytic action of the metal. Where the voltmeter, on the contrary, shows that the pipe is electro-positive to the ground, i. e., that there is a fall of potential between the pipe and the ground, the pipe is known to be in danger, since current will tend to flow from the pipe out into the ground and will dissolve the iron or lead as it does so.

The necessary tools for this test (besides a voltmeter with a scale reading up to about 15 volts) are two poles with metal terminals for making contact with the metal to be protected and earth. In testing water pipe or cable for electrolysis, the pipe or cable can generally be reached only at intervals—through manholes in case of cables and at fire plugs or house pipes in case of water or gas pipes. The pole for making contact with pipe or cable should terminate in a steel point, rather sharp. The force necessary to exert for making good metallic contact can be determined after a little experimenting.

The poles should be made long enough for convenience in testing, thus, in testing cables in manholes one of them should be long enough to enable the tests to be made without necessitating going into the manhole to make the contact on the cable. An insulated wire is led from the metal terminal of the pole, via the opposite end, to the voltmeter, the wire being permanently fixed to the pole and a soldered connection made to the metal terminal. For earthing one voltmeter terminal, contact with earth must be made with the same metal as that on which tests are being made, as otherwise galvanic action will occur between the earthing terminal and the system being tested. In such cases a voltmeter indication would occur, although electrolysis of the pipe, due to earth currents, were not taking place, the result being to increase the danger readings and decrease the safe readings—or vice versa—depending on whether a metal electro-positive to the piping system or one electro-negative were used for earthing the voltmeter. In testing the lead-covered cables belonging to electrical companies the contact with earth can conveniently be made through the water or mud that is usually to be found at the bottom of the manholes. The contact should be made by means of a piece of lead, either in sheet or pipe form, lowered by means of the attached wire or pole into the water of the manhole.

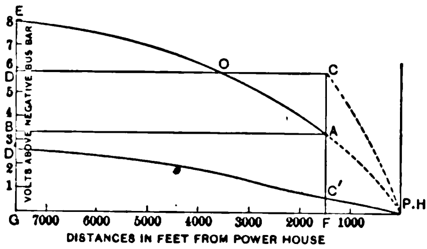
The voltmeter used should have a scale reading up to about 15 volts, the higher the resistance of the voltmeter the better, as a low-resistance voltmeter is likely to have its indications considerably reduced by the resistance of the ground connection in series with it.

In testing a system of any considerable size a large number of points should be taken the first time the system is tested—say points from three to five hundred feet apart—and afterward those previously found safe can be omitted unless reasons exist for believing them to have become dangerous. In general, tests should be made at intervals of six months or a year at the longest, and whenever changes in conditions of distribution of power are known to have occurred.

The results obtained from these tests may be plotted in the form of curves showing the distribution of the potential drop over the pipes and adjacent ground. Fig. 2 is a plot of such a set of curves for a simple single line of piping or cable sheathing, vertical distances in the figure representing electromotive forces and horizontal distances (read to the left from the point P H) representing distances in 1000 feet from the power house. The length from P H to the point, F, represents the distance from the power house to the nearest point of the pipe, while the length, F G, represents distance measured along the pipe to its most distant end, G. The lowest or zero line of the plot, running from G to P H, represents the lowest potential to be found, i. e., that of the negative bus bar in the power house. All distances above this line represent volts rise of potential.

The line, D C, represents the potential of the pipe under consideration, i. e., the length, C F (which is about 5½ volts), shows the electromotive force between the pipe at point F and the negative bus bar. This e.m.f. can, in many cases, be easily determined by means of some pilot or insulated signal or telephone wire, or even a feeder of the traction system which is not carrying current. As a rule, the line, C D, may be assumed to be horizontal when the pipe is not connected metallically to the traction company's return system; that is to say, it may be assumed that there is no fall of potential in the pipe between the most distant end, G, and the nearest end, F. This would be approximately true because—although there will be some current leaking into the pipe from the ground at the distant sections and leaking out from the pipe into the ground at nearer sections—this current will not be sufficient to cause any considerable fall of potential in the pipe. If the latter is a cable sheath or other pipe of continuous metal, without joints, there will be practically no fall of potential along it, although in the case of cast-iron gas or water pipes having joints with low conductivity there may be considerable fall of potential due to these resisting joints. Assuming, however, for the present discussion, that there is none, point D will have the same potential and consequently the same height on the diagram as point C.

By means of measurements with the apparatus described above the difference of potential between pipe and ground at various points may be determined. At the end most distant from the power house it may be found that there is a fall of potential of 2½ volts between the ground and the pipe. Then the ground at this point would show a difference of potential equal to E G or 8 volts above the negative bus bar. At other points nearer the power house the potential of the ground will fall until finally such a point as O is reached, where there is no difference between the potential of the ground and that of the pipe. At points still nearer the power house the ground is below the potential of the pipe until finally at the nearest point to the power house the potential of ground has fallen off to height of point A, or about 3¼ volts. This will be determined by the voltmeter showing a fall of potential between pipe and ground equal to C A, or about 2¼ volts. It is obvious that at all points to the left of O, i. e., further away from the power house than point O, the potential of the ground is above that of the pipe, i. e., any flow of current would tend to be from the ground into the pipe, while at all points to the right of O, i. e., nearer the power house, the potential of the ground is lower than that of the pipe, i. e., the direction of any current flowing is from the pipe into the ground. Thus at all points to the left of O the pipe is safe, while to the right of O it is in danger.



American Electrician

FIG. 2.—PLOT SHOWING DISTRIBUTION OF POTENTIAL OVER A PIPING SYSTEM AND ADJACENT GROUND BEFORE AND AFTER RUNNING AN INDEPENDENT RETURN.

It will be noticed that the slope of the ground line, E O A, increases as it approaches the power house. This is, as a rule, the case where a pipe runs out in a direction nearly straight away from the power house, since there is more current returning in the street car rails and return feeders near the power house than in the rails at distant points, causing a more rapid fall of potential in the nearby districts than in the outlying districts. This is not the case if the traction company reinforces its return circuits on the lines adjacent to the power house in order to accommodate this increased current on these lines without a more rapid fall of potential, but this is rarely, if ever, thoroughly done. Other cases where the fall of potential along the pipe does not become more rapid as the power house is approached, occur when the pipe runs not toward but past the power house. In this case the line of potential of the ground becomes less and less steep as the pipe approaches its nearest point to the power house, becoming at somewhere near that point horizontal and then beginning to rise again as further points along the pipe begin again to recede from the power house.

Suppose now that a copper wire having the same resistance per foot as the pipe be run from the end, C, of the pipe to the bus bar at the power house. Then, if it happened to be the case that the ground around the whole length of the pipe were perfectly dry, allowing so little current to leak into the pipe that there would be no appreciable drop in the pipe and the return wire from the pipe to the power house, the whole pipe would fall to the potential of the negative bus bar and its line of potential would become G F. Readings with a voltmeter would, in this case, show at the point, G, a fall equal to E G, or 8 volts between surrounding ground and the pipe, and a fall at F equal to A F between ground and pipe. However, the ground is always moist and a certain amount of current is picked up by the pipe, in this case a great deal more than in the former, when the pipe was not metallically connected with the return circuit in any way, since in this case there is a free low-resistance path out of the pipe into the return circuit, for which reason current tends to leak into the pipe for a much greater portion of its total length and with a much increased electromotive force. On this account enough current enters to cause a considerable drop in the pipe. For this reason the line of potential of the pipe may assume the form, D′ C′, sloping more rapidly as it approaches the power house, owing to the additions of current all along its length. The line from C′ to P H represents the fall of potential in the auxiliary return.

With this new return circuit through

the pipe to drain current out of the surrounding ground the potential line of ground will fall somewhat, but neglecting this fall the voltmeter will, under the new conditions, give at the distant end of the pipe the reading, E D′, about 5½ volts, and at the near end of the pipe the reading, A C′, about 2½ volts, intermediate points showing intermediate values. It will be seen that the potential of the whole length of the pipe is below that of the ground adjacent to it and no current therefore can flow out of the pipe into the ground, hence the pipe is safe.

In the preceding argument we have assumed that the negative bus bar was the most suitable point for the connection of the return. It is, nevertheless, apparent that if some other line of material of sufficiently low resistance were more convenient as a path for the return of the current to the negative bus, we might make use of it in place of the copper return. It very often happens that it is much easier and cheaper to make use of the traction company's return circuit instead of running an auxiliary return the whole way to the negative bus—provided, of course, permission can be obtained for attaching to the traction company's return system. This is allowable only if the potential of the track at the point of attachment is below that of the earth by a sufficient amount to pull down the potential of the whole pipe, cable or piping system connected below the earth surrounding it. If, for example, the railroad company's return consists solely of the rails, not reinforced by any copper cables, and these rails have a few bad joints between the power house and the point of attachment, the potential of the rails at this point may be above that of the surrounding earth, notwithstanding its being below that of the pipe, in which case the pipe would remain in danger after being attached.

In case of the attachment of a single pipe with only a few milliamperes flowing, it would not add sufficient current to the track return to appreciably change its potential with respect to the earth. However, it may so happen that the pipe is a branch from a vast system of underground piping. In the latter case the amount of current collected by this system and brought in through the attachment may amount to hundreds of amperes, and this current, added to that in the track, might raise the potential of the track and thus bring the potential of the line of pipe at the point of attachment above that of the earth. In such cases the running of a return toward the power house must be resorted to. By this means the potential of the pipe can be brought down because the current density in the auxiliary return can be kept much lower than that in the traction company's return. Thus the fall of potential in the auxiliary return per 100 feet of length can be made lower than in the traction company's return which it parallels. This case is shown in Fig. 3, where it will be seen that if the piping is attached to the traction company's return, at point A, there will be a dangerous condition of the pipes between pipes A and B. If, however, the auxiliary return is run from point A down to a point such as C (not necessarily as far as the negative bus bar itself) the potential of the whole pipe, which is assumed to lie entirely to the left of A, is brought below that of the ground, and thus the pipe is rendered safe. It will be seen that in this diagram the ground has a lower potential than the adjacent track throughout its length. This may be the case through the provision of other auxiliary returns, which, so to speak, collect the current out of the ground and drain it away, thus lowering the potential of the ground. For instance, a telephone company may at one time make tests and find that its system is, on the whole, safe, and a little later find that a highly dangerous condition exists. This sudden change may be due to a lowering of the potential of the ground below that of the track by auxiliary returns run by some other corporation operating over the same territory, such as a water or gas company. This is a condition to be watched for at all times, as the protection of one set of pipes is likely to cause danger upon another.

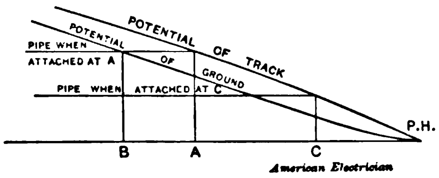


FIG. 3.—PLOT SHOWING SAFE AND DANGEROUS CONDITIONS, WITH GROUND BELOW ADJACENT TRACKS.

The difference between electrolysis of the sheath of a cable and a hole burned into the cable sheath by a heavy current can be very easily seen. The edges of the hole burned into a cable sheath are square as though the hole were punched into it. Those of a hole made by electrolysis are generally thin like the edges of a dull knife blade. Electrolysis always causes grainy, rough surfaces where it occurs. Its apparently freakish tendency to attack in spots and form ridges is due to a lack of homogeneity in the metal or in the electrolyte.

In most cases it is impossible to determine the resistance of the traction company's return circuits; consequently how near to the power house it will be necessary to run a return and just what the cross-section of the return should be are matters of speculation to a greater or less extent. A safe rule to follow in average cases as to the cross-section of the auxiliary return is to make it of the same conductivity as the line of piping or cable sheathing to be protected. If the line to be protected is short, and consists of only one or a few small pipes or cables, the auxiliary return may be small, while if the line to be protected is a branch from a large network extending for a long distance, it may pick up a great deal of current and the auxiliary return should be correspondingly large. Several trials will often be necessary, followed, in each case, by voltmeter tests between the pipe and ground at several points to determine whether the proper condition for safety has been attained. If not, either the cross-section of the return or its length toward the negative bus bar, or both, must be increased. Naturally it will do little good to increase the cross-section of the auxiliary return if there is but a very small flow of current in it, and consequently a small drop of potential. Increased cross-section in this case would not appreciably lower the voltage of the piping which the auxiliary return drains.

For measuring currents and the fall of potential in returns a milli-voltmeter can be used conveniently. By measuring the voltage between two points a few feet apart on the return, the current can be calculated on the basis of 10 ohms per foot per circular mil. This obviates the necessity of cutting the return to insert an ammeter, which requires that the point cut should afterward be soldered, leaving a joint which is likely to corrode away.

Where the current in the auxiliary return is large and the fall of potential nearly as rapid as that in the track return, it is obviously of comparatively little use to run a return further toward the power station. In this case the cross-section of the return should be increased, thus reducing the drop in the return. The fall of potential along the track can be determined by means of a milli-voltmeter and compared with that along the return to determine whether to lengthen the return or increase its cross-section.

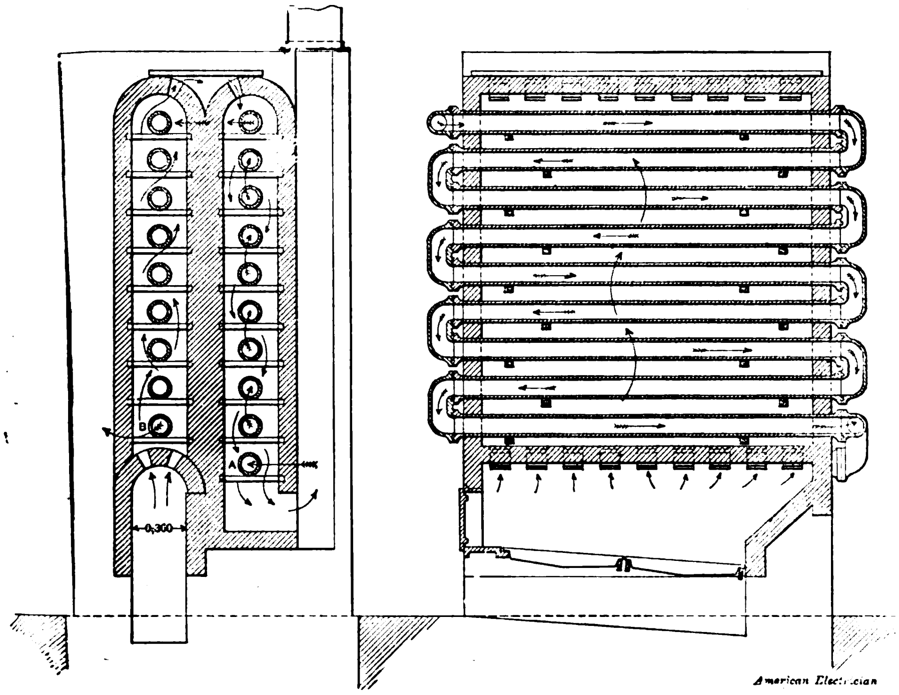
A very convenient material for underground returns is flexible copper strands tinned. Besides being convenient for pulling through ducts, underground, it permits of easy and certain connections. In case it is to be pulled into underground ducts it is generally safe not to insulate it. The rules to be followed for its protection in most cases are the same as for the protection of cable. The returns should be attached to the cable sheath by means of a wiped joint and should be connected to the traction system either by a soldered joint to cross bonds or return feeders, or by a bond to the track itself.

In the case of complicated networks of cables, pipes and return circuits, the proper protection can only be predetermined by experience and familiarity with conditions, and even then a certain amount of experiment will be required. A complete plot of the distribution of potential between piping and adjacent ground—laid out as are the plots given above—combined with a study of the relative potential of adjacent points on the traction company's return will allow the best locations for the auxiliary returns to be determined so as to spend least for copper. After these returns are in, any points that are shown by the tests to remain dangerous can be protected by additions to the return system.

THE ADVANTAGES OF SUPERHEATING AND THE SUPERHEATER OF THE UNIVERSITY OF LIEGE.

BY GEORGES DUCHESNE.

A great reduction of the efficiency of steam engines is caused by initial condensation. To this phenomenon is traceable the greater part of the waste of steam engines which it is theoretically possible to save. The heat delivered during admission to the cylinder walls by condensation of hot steam upon them is partly restored and utilized by a partial re-evaporation which takes place during expansion, but is returned at a lower temperature, i. e., at a lower thermal potential, and its capacity for doing work is correspondingly diminished. On the other hand, a large part of the heat absorbed by the cylinder walls is not restored at all, but passes directly to the condenser by re-evaporation of the condensed water on the cylinder walls during the exhaust stroke. This heat passes through the steam engine from the boiler to the condenser without doing any useful work.



SECTIONS THROUGH THE SUPERHEATER OF THE UNIVERSITY OF LIEGE.

The superheater is the most powerful means at our disposal for reducing this initial condensation. Superheated steam before it can be condensed by the cooling effect of cylinder walls, heads and piston, must give these parts the thermal energy stored up in it due to its increased temperature above that of saturation. In addition to this it has been shown experimentally that the transmission of heat between metallic surfaces and steam take place some 10 or 12 times more rapidly if there is upon the metallic surface a film of water.

The considerable reduction of the initial condensation which a small superheater, in itself apparently insignificant, can accomplish, allows the almost complete realization of the principle of maximum economy laid down by Prof. Dwelshauvers Dery, as follows: "The most economical working of a steam engine is obtained when, by any means, the metal of cylinder walls is absolutely dry at the beginning of exhaust; in other words, if the expanded steam is, at release, just dry or slightly superheated, so that no part of it is condensed in the form of a film of water on the walls."

It is impossible to give a general rule by which the saving due to superheating can be predetermined, but the numerous tests made by experimenters well known to the scientific world allow no doubt that it effects a considerable saving of fuel.

As in all industrial processes, the numerous advantages of superheating are offset by quite serious inconveniences.

These are, to begin with, the first cost of the superheating apparatus, its maintenance, to which may be added the loss of heat by radiation and convection from the superheater itself. Also on account of the low heat conductivity of steam, the piping, exposed to the direct action of fire, works under difficult conditions, deteriorates rapidly and increases, in consequence, the necessity of renewals and consequent shut downs. There remains yet to be given one more inconvenience, even more serious. Cylinder lubricating oils do not resist well the high temperatures; they disintegrate at about 250 degrees C. In consequence the wear of valves, pistons and rods becomes serious and the mechanical efficiency of the engine falls off.

On account of failure to properly appreciate the serious extent of the exchange of heat between the steam and the cylinder walls there has grown up a general belief that the increased economy due to superheating would be more than offset by the disadvantages mentioned above, and superheating, which was first proposed some three-quarters of a century ago, was early abandoned. Of late, however, an idea has grown up that superheated steam will take the important place which legitimately belongs to it and that its introduction waits only the perfection of certain details.

To show the increased economy that may be expected, a few authentic cases may be cited. In Lagelbach, M. Hiry has experimented with a superheater placed in front of the boiler, the pressure being 56 pounds per square inch, and the temperatures of the superheated steam at various times 210, 225 and 245 degrees C. The saving of fuel over and above that used with saturated steam amounted for these three temperatures to 20, 31 and 47 per cent. In spite of these remarkable results, Hiry's work was not followed up in Europe, manufacturers preferring to devote their energies to the use of higher pressures for the attainment of increased economy.

To show to what extent pressure must be carried to obtain a corresponding economy, the following comparison is not without interest. The quadruple-expansion engine of Sibley College, New York State, working with saturated steam at a pressure of 300 pounds per square inch, uses 9.5 pounds of steam per indicated horse-power hour, while the Schmidt compound engine uses but 10 pounds of superheated steam under a pressure of 190 pounds per square inch. While the latter pressure can be commercially used, those of 300 pounds or more, which so far have only been employed in laboratory tests, do not appear to be industrially practicable.

To cite the results of other trials; in Alsace, where the employment of the superheater is unusually advanced, trials made in 1893 by M. Hausmann at Lagelbach have shown a reduction of fuel consumed of 17.6, 18.5 and 20.1 per cent. In the same year, in France, the tests made by M. Roche, a French naval engineer, on boilers fitted with Dusert & Epeche superheaters, have shown a saving of fuel varying from 19 to 36 per cent. In England, tests made in 1895 and described by Mr. Patchell, show an average fuel saving of 20 per cent. Lastly, a Schmidt superheated-steam engine has been shown to use an average of 8.5 pounds of fuel (12,500 B. T. U. per pound) per indicated horse-power hour, and the great popularity which this make of engine already enjoys in Europe bids fair to increase the use of superheated steam.

As yet we have said nothing as to the means of obtaining superheated steam, and there is not room here for a description of the various forms of superheaters. As is well known, steam can be superheated by a reduction of pressure or wire drawing, a means which is of little more than theoretical interest. In this connection it is interesting to note the superheating by throttling in Willans engines, where the steam is reduced in pressure before reaching the cylinders. In commercial work superheating is accomplished by passing the saturated steam into heating tubes exposed directly to the heat of the furnace or to the hot gases leaving the boiler, or heated by a separate furnace quite independent of the boiler. The choice between these alternatives depends, in any individual case, upon the conditions.

In a steam-engineering laboratory one condition more important than all others is the necessity of running the engine and boiler with or without the superheater so as to obtain comparative results. The mechanical laboratory of the University of Liege contains a superheater which, on this account, is heated independently of the boiler. This superheater is described below, with illustrations of some details. The results of trials of this superheater are also given below to show what can be obtained from such apparatus.

The superheater itself (see the illustration on page 75) consists of a brick furnace and combustion chamber lined with fire brick and divided by a partition into two parts, the hot gases circulating upward through one and downward through the other on their way to the stack, as the arrows in the illustration show. These two chambers contain 19 horizontal cast-iron tubes, with a useful length of 7 feet. Their external diameter is 6 inches, and the thickness of the tube shells is about an inch, leaving an internal diameter of approximately 4 inches. The heating surface of this apparatus amounts to 215 square feet, while the grate surface is 6.2 square feet. The saturated steam is led in after being passed through a separator at the point, A, nearest the outlet of the gases, and circulates upward through one tier of tubes and downward through the other to the point, B, nearest the furnace, the circulation of the steam being thus against that of the gases.

The means adopted for joining the ends of the tubes is interesting, this being accomplished by cast-iron return bends provided with flanges for bolts, and with a circular projecting ring on the surface of the tube flange and a corresponding circular recess in the return bend to prevent leakage of steam, as shown in the detailed illustration. Only two bolts are used at each joint.

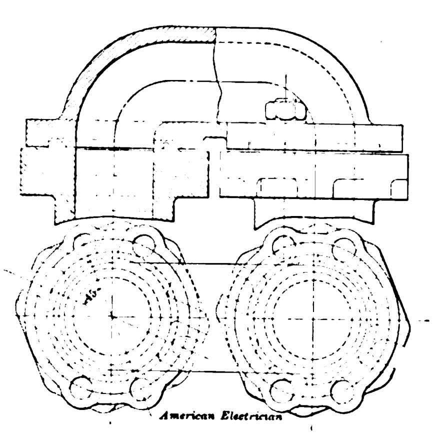
It should be noticed that the tubes are not equally exposed to the action of the heat on all sides, but are subject to a fierce heat on half of their circumference, the other half being covered with soot. On this account they are heated unequally and are subject to a bending strain. To diminish this cause of alteration there is provided an arrangement for occasionally turning the tubes about their longitudinal axes. The design adopted provides for eight different radial positions, the minimum angle of rotation being 45 degrees. This is obtained as shown in the accompanying detail drawing, by means of four bolt holes, spaced 90 degrees apart, around the flange of the tube, and four bolt holes placed at the end of two diameters, making an angle of 45 degrees with each other on the return bends, as the illustration shows.

On the 16th and 17th of October, 1899, the experimental engine of the laboratory was run under practically the same indicated and brake load for the two days, the first day with superheating and the other without. The data of these tests are given in the following table:

	Oct. 16.	Oct. 17.
Cut-off (per cent of stroke)....	10	10
Compression (per cent of stroke)	60	60
Steam jacket	None	None
Condenser	In use	In use
R. P. M.	45.33	48.70
Indicated horse power	13.56	14.49
Brake horse power	12.25	13.02
Mechanical efficiency of the engine	0.897	0.899
Temperature of the entering steam	199.8°	158.8°
Pressure (lbs. per sq. in.)	84.0	86.1
Temperature of saturation corresponding to this pressure..	157.8	158.8
Superheat	42°	0°
Total heat per kilogram of steam (calories)	675.0	564.9
Temperature of water leaving condenser	21.3°	22.4°
Heat per kilogram of this water (calories)	21.3	22.4
Heat given up to the engine per kilogram of steam........	653.7	632.5
Kilogram of steam per stroke of piston	0.0266	0.0318
Heat given up to the engine per this weight of steam.....	17.4	19.5
Equivalent in calories of the work done per stroke........	1.58	1.58
Thermal efficiency of the engine	9.09	8.07

Saving due to superheating, 11.25 per cent.

As stated above, this installation was not designed to obtain economy, and further, on account of local conditions, the fuel economy of the boiler itself is poor. On this account a comparison between the amount of fuel used in the two cases would not be a guide as to what could be obtained in commercial practice.



DETAIL SHOWING PROVISION FOR ROTATING CAST-IRON TUBES OF SUPERHEATER.

A LIFE TEST OF INCANDESCENT LAMPS.*

BY GEO. D. SHEPARDSON.

In order to discover what is likely to be the experience of the buyer who lacks either the ability or the inclination to test all lamps received and to reject those which do not meet his specifications as to candle power and wattage, the following experiments were carried on in April and May, 1899. To secure average conditions prevailing in the Northwest, lamps rated at 16 c.p. were picked at random from the stocks of the Minneapolis General Electric Company, the St. Paul Gas Company, the Faribault Gas and Electric Company, the Owatonna Electric Company, the Electrical Engineering Company of Minneapolis, and from the agents of two lamp factories which were already represented by lamps secured from other sources. Current was kindly furnished by the Minneapolis General Electric Company. The experiment was conducted by Henry A. Hildebrandt and Arthur C. Pratt, senior students in the University of Minnesota. The lamps were run on an alternating current line whose voltage was maintained constant within a range of 2 volts, a recording voltmeter giving a continuous record of the fluctuations. The candle power, wattage and efficiency of the lamps were determined with direct current and a Lummer-Brodhun photometer with Weston voltmeter and Whitney milliamperemeter which were calibrated before and after the test. The standard of light was a well-aged incandescent lamp which had been standardized by a certified amyl acetate lamp and by standard candles, being frequently checked by a second and similar standardized incandescent lamp.

Ten lots of lamps from seven lamp factories were first tested for candle power and wattage at their marked voltage. The initial candle power of the 55 lamps varied from 14.1 to 23.0, while the watts per lamp varied from 47.3 to 71.3, the watts per candle varying from 2.32 to 4.10. The average candle power of the lamps of each group varied from 15.2 to 22.0, while the average watts per lamp varied from 49.0 to 66.4, and the average watts per candle varied from 2.42 to 3.60. The general average for the 55 lamps given a preliminary test gave 18.3 c.p. at 55.8 watts, or 3.1 watts per candle. This indicates that the central stations in this association are using lamps of higher efficiency than was common a few years ago, also that there is still a wide range in the candle power, wattage and watts per candle of the lamps in use. It might be noted that the watts per candle were specified on only one lot of lamps, another being called "of standard efficiency," while a third lot was called "high efficiency," the latter taking about 3 watts per candle.

The different lots of lamps were marked A, B, C, D, E, F, G, H, and I, and four lamps were selected at random from each lot except I and H. The ratio between the mean horizontal candle power and that in a certain marked position was carefully determined. Lamp sockets were wired to heavy leads and resistances were adjusted so that each lamp received the voltage marked on the label. The sockets were placed so that the lamps were horizontal and each lamp was always placed in the same socket in order to make the conditions of drooping alike for all. At intervals of about 24 hours, each lamp was removed to the photometer and tested for candle power and current. Each lamp was allowed to burn until the end of the test or until it broke or met an accident. It was not thought advisable to throw out each lamp when it dropped to 80 per cent of its initial candle power, since it is believed to be the exception rather than the rule for the smaller stations (not excepting most of the larger) to pay much attention to the "smashing point" or economical life of an incandescent lamp unless a customer complains about poor light.

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*Abstracted from paper read before the Northwestern Electrical Association.

After burning about 50 hours, it is found that the light varies from 8.2 to 23.0 candle power, while the watts per lamp vary from 45.7 to 72.1, the watts per candle varying from 2.32 to 4.10, the general averages being 17.5 c.p. at 55 watts per lamp and 3.27 watts per candle.

After about 100 hours, the light varies from 10.1 to 22.3 c.p., the watts from 45.5 to 72.1 per lamp and from 2.52 to 5.02 per candle. The general averages are 17.5 c.p. at 55.3 watts per lamp and 3.30 watts per candle.

After about 400 hours, the light varies from 11.3 to 19.0 c.p. at 46.6 to 70.2 watts per lamp and 3.00 to 4.31 watts per candle. The averages give 16.0 c.p. at 56.5 watts per lamp and 3.54 watts per candle.

After about 600 hours, the lights vary from 11.4 to 18.8 c.p. at 44.0 to 69.9 watts per lamp and 3.34 to 4.26 watts per candle. The averages give 14.7 c.p. at 55.6 watts per lamp and 3.82 watts per candle.

A few lamps were burned 800 to 900 hours, after which time the candle power varied from 10.8 to 16.4, while the watts per candle varied from 3.60 to 4.40.

Early in the test it was noted that several of the lamps "burned blue" and their high efficiency pointed to an early demise. All four of the lamps of Lot A had burned out in about 100 hours and none of those in Lot B lasted more than 500 hours, only one of them lasting 350 hours. These two lots were from lamps bought by a large company which contemplated changing lamps, and it is not certain whether these lamps were high-economy lamps sent for trial or whether they were lamps intended for lower voltages, but marked to suit the voltage ordered. Their performance suggests that the lamp makers find it necessary to dispose of their product and must mark their lamps to suit orders if the orders persistently call for lamps of the same standard voltage. It emphasizes the request made by some of the lamp makers that stations would find it to their advantage to adopt some odd voltage in order to use the lamps which must be made to supply other standards.

To get some comparison between the behavior of lamps on constant potential circuit and those on a circuit with poor regulation, several lamps were placed on a circuit varying from 104 to 118 volts. The lamps so placed were not sufficiently numerous to give close conclusions. The high efficiency lamps all died within about 300 hours, while most of their mates of like make on the well-regulated circuit were in fair condition at 800 hours. The candle power and efficiency of the lamps on fluctuating circuit fell in 300 hours as much as did that of the lamps on the constant potential circuit in 800 hours. The lamps on the circuit with voltage fluctuating 13 volts aged at least three times as rapidly as their equals on a circuit fluctuating 2 volts. Such a statement can only give a rough idea of the general effect since the result of a fluctuation depends upon whether it varies above or below the normal. The lamps of low initial efficiency (that is, those which took 3.5 to 4.0 watts per candle) withstood the extreme variation much better than did those of higher efficiency, as was to be expected.

After the above test had been ended, some of the lamps were placed on the photometer and the voltage was raised until the candle power equalled the initial value. Three lamps marked for 108 volts were raised to 111.4 volts, to 112.6 and to 112.6 volts to restore them to their initial candle power. Another lamp marked for 110 volts, which had burned 558 hours on the circuit with widely fluctuating voltage, was raised to 120 volts before its candle power equalled that of its youth. The efficiencies of these lamps at the higher voltage were from 1 to 8 per cent lower than their original efficiencies. This seems to justify the practice of some engineers who move old lamps to places on the circuit having higher average voltage. To what extent the economical life of a lamp may be extended by raising the voltage from time to time, is a matter that seems worth investigation. In this connection it should be stated that very few of the lamps showed any considerable blackening, so that the loss of light and efficiency with age seem to come more from change in the filament than from absorption by the coating inside the bulb.

As a matter of interest, several lamps were gathered from various sources and their candle power measured while dirty with the accumulations of time and after the same were washed off. The light was increased from 1 to 30 per cent.

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IMPROVEMENTS IN THE THREE-WIRE SYSTEM.

BY ALTON D. ADAMS.

The Edison three-wire system, one of the earliest methods of constant pressure distribution, has grown steadily in application and importance with the development of electric stations. The introduction of storage batteries and of the alternating-current system have each served to widen the field of three-wire service, so that to-day there are few large stations that do not employ this method of distribution at some points. While the general principles of three-wire distribution have remained constant, the practical methods of its use and regulation have undergone fundamental improvements. Some of the changes relate only to construction, others solely to operation. During some years after the inception of the three-wire system its underground construction in this country was carried out almost entirely with the Edison tubes. These well-known tubes are of iron, twenty and one-half feet long, and each contains three copper conductors separately wound with jute cord and all embedded in asphaltum. Joints between the conductors occur for every length of tube and are made by short flexible cables that are soldered to the copper rods where they extend beyond the iron tubes. To join the tubes, iron coupling boxes are used and filled with hot asphaltum after the copper rods are joined. The Edison tubes are laid directly in the ground, and that part of the system known as the mains is tapped at all desired points for service to consumers. The facility and cheapness with which connection may be made with an Edison main commends it at once to practical engineers and has, no doubt, been a large factor in the retention of the system. Consumer's connections to mains often occur within a few feet of each other and it is quicker and less costly to tap an Edison main than a lead-covered cable in a conduit. A three-wire distribution system for public service is usually composed of two quite distinct parts, the main to which service connections are made and the feeders which connect the generating stations with the mains at various points but are not tapped to supply customers. The feature of frequent joints and coupling boxes, so convenient in mains, is, therefore, of no particular advantage in feeders, but is, on the other hand, a decided disadvantage, for the following reasons. The loss of energy in the mains of a three-wire system is necessarily kept at a comparatively low point in order to maintain a fairly uniform pressure at the lamps. By far the greatest distribution loss is that in the feeders, and this, at times of full load, is not infrequently of sufficient amount to materially raise the temperature of the copper conductors in the tubes. If any of the many joints in Edison tube feeders are not made in the best manner they are apt to be melted at times of heavy load and an open circuit thus produced. The interruption of service and the cost of repairs by troubles at the joints of Edison tubes on important feeder lines has led to the adoption of lead-covered cables for feeders in much recent work, and this latter may be regarded as the best practice to-day. The Edison tubes are usually retained for mains, however, where their advantage is greatest.

Owing to the varying conditions of load at different points on the mains of three-wire systems, and to the unequal length of the several feeders, it is a common condition of operation that the losses of electric pressure in the feeders are not constant, or all the same, at any one time. It is therefore necessary that some feeders leave the generating station with higher pressures than others. It was not formerly desirable to use different generators, operated at several pressures, on the several feeders, as this made multiple connection impossible. It was, therefore, often the old practice to connect a variable resistance in the circuit of each feeder at the station and supply all feeders from a common bus bar. Pressure wires run back from the point where each feeder joins the mains, give a constant indication of the voltages at these points, and an adjustment of the variable resistances in the several feeder circuits tends to keep the pressure constant on the mains. With this method of regulation the voltage at the station bus bars must be high enough to allow for the greatest loss in any one feeder and the excess of pressure at all of the other feeders must be taken up by their variable resistances. The energy spent in heating the variable resistances is evidently a total loss, and its amount is considerable at times of heavy load.

As storage batteries came into general use at direct-current constant-pressure stations a more satisfactory method of compensation for the various pressure losses in different feeders was developed.

As the pressure for each cell of storage battery is only a little more than two volts, it is possible to obtain almost any voltage within the battery capacity by connections that include different numbers of cells. When a battery is relied on to meet the requirements of feeder regulation, several sets of bus bars are usually arranged to connect with the battery at the desired points. The number of batteries connected to each bus bar determines its pressure, and the several feeders are divided among the different bars according to the pressure loss in each at any particular time. While a battery is thus used to give each feeder current at just the desired pressure, the electric generators may be, and frequently are, connected to the battery so as to give the desired output and keep it partly charged.

The battery method of feeder regulation has disadvantages, among which are the large capacity of batteries required and their internal losses. The best and most widely used means for the supply of feeders at varying pressures, at the present time, is that of separate bus bars for each pair of generators, and motor dynamos, or boosters, for the transfer of energy from one set of bus bars to another. It is very important for steam economy in three-wire, as in all electric stations, that the dynamos be operated in multiple, so as to keep all of the engines in use at any one time at nearly full load. Before batteries or boosters came into use for purposes of regulation, there was no satisfactory means for the transfer of electric energy from one bus bar to another of different pressure. It was the early station practice in large plants to provide several sets of bus bars, operated at different pressures, and to connect each feeder with the bar nearest to its pressure requirements. Electric generators were connected by pairs to one or the other of the several bars, according to the load on each, and underloaded generators on one set of bus bars could, obviously, not be used at the same time for another set because of the difference in pressure. A result was that the generators were often worked at light load in order to maintain the several desired pressures. Though undesirable results as to conditions of loads were frequent in the older three-wire stations, the effects were not nearly so bad as they would be in more recent plants, did no means exist for the economical transfer of energy from one bar to another at a different pressure. The greatly increased size of generating units is a factor which makes energy transfer from bar to bar more necessary than formerly. The older three-wire stations were equipped with dynamos of from 60 to 200 kilowatts each and from 10 to 20 machines were frequently found in a single plant. With these comparatively small generators any considerable change in load can be followed at once by a variation of the number in operation so as to insure a large per cent of full load on all engines in use. Central station practice has tended constantly toward larger units, however, and generators up to three, five, and even eight hundred kilowatts capacity are now in common use, while the average number of machines in a station of given capacity has greatly diminished. A very material change in the station load is obviously necessary to warrant a variation of the number of these large units in operation, and to run at a low stage of load means very poor economy of steam.

The frequent practice is to drive a pair of these large electric generators with a single compound engine, and to provide a set of bus bars for each pair. On this plan, as many station pressures are available as there are pairs of generators, and each feeder is connected to the bus bar of that generator which is furnishing the desired pressure. As the voltage necessary for the several feeders frequently changes, a given feeder may be on one bus at a certain time of day and on another bus at a different time. It frequently happens that more feeders require the pressure of one bus than its connected generators are able to supply, while on one or more other bus bars the load is much below their generator capacities; or, again, that a voltage is required which differs from that of any bus, while there is ample unused capacity in some of the operating generators.

The motor-dynamo effects a most satisfactory solution of these conditions through its ability to take electric current from any set of bus bars at the existing pressure and deliver current to any other bus bar at the voltage desired. This use of motor-generators makes it possible to supply any number of feeders with different pressures from the same generators and thus operate with the smallest number of engines and dynamos competent tc carry the station load at any particular time. Under the old system of feeder regulation by variable resistances, all of the energy taken from bus bars that was not required in feeder circuits was dissipated as useless head in the regulating coils. Motor-dynamos, on the other hand, may readily deliver at the generator end 75 to 80 per cent. of the energy absorbed at the motor end, and have the further advantage that they can be used to raise as readily as to lower the pressure. One of the distinctive features of the three-wire system is its tendency to automatic regulation of pressure for unequal loads between each outside wire and the neutral. The regulation would be perfect were it not for the fact that with unbalanced loads the drop of pressure in the two outside wires is not equal. To insure good pressure regulation at the lamps it is necessary to keep the load divided as nearly as possible between the two sides of the system, and rely on its inherent properties of regulation to the smallest extent possible. So much attention is now given to the matter of uniform loads on the two sides of the three-wire system that only a small part of the total station capacity is concerned in the process of regulation at any one time. In other words, a very large part of the output in well-regulated three-wire stations travels on the two outside wires and but little on the neutral.

The continued extension of the areas served from plants operating on the three-wire system has rendered more complex the problem of good regulation at the lamps. Increase in the radii of service from a single station has been further increased by the marked tendency to concentrate all engines and generating equipment at one point. Formerly it was not uncommon to find generating stations at several locations in a three-wire system, but the best practice has now changed to one main generating plant and as many sub-stations or distribution plants as are thought desirable.

Large direct feeders that have immediate connection with the general system of mains are run between the generating plant and all of the sub-stations, so that energy can be sent to any sub-station without any necessary effect on the surrounding network of mains. These large feeders direct from the generating plant to the sub-stations are supplied with current from bus bars that are usually at higher pressure than the rest of the system, so as to compensate for the greater loss of transmission to the distant parts of the system, where the sub-stations are usually located. Feeders between stations are usually run with but two cables, the third wire being omitted and the necessary regulation of pressure to keep the system in balance depending on the proper use of batteries and motor-generators at the sub-stations.

In order to avoid the large loss of transmission at times of maximum load and keep the necessary capacity at the generating station as low as possible, the batteries at sub-stations are given most of their charge during the hours when the public demand for current is comparatively small. At times of heavy load the battery at each sub-station acts with the supply then received from the generating station to carry the total load.

The motor-dynamos at the sub-stations are used either to transfer energy from one bus bar to another at a different voltage, or to transfer energy from one side of the three-wire system to the other, in order to maintain an equal load on each.

The tendency to maintain a balance between the two sides of the three-wire system by shifting feeders from one outside wire to the other, and also the use of but two wires in transmission to sub-stations from the main plant, has developed the use of generators operating a double or more than double the voltage of the ordinary generators in a three-wire plant. That is, instead of the pressure of about 125 volts common for generators on each side of the three-wire system in this country, this latter type of generator works at a pressure of from about 250 to 300 volts. The lower of these two pressures is generated when the machine is connected directly with some of the feeders that run directly to service mains, while the higher voltage is used when the generator is supplying a heavy load to the feeders that connect the generating station with the sub-stations. Several advantages attach to the use of these double pressure generators. Dynamos at the pressure of 125 volts must usually be connected or disconnected with the three-wire system in pairs, so as to maintain an equal capacity on each side, and each generator must, therefore, have only one half the output by which it is desired to vary the operating equipment at one time. The 250 to 300-volt generators may, therefore, properly have double the capacity of one at 125 volts, and thereby effect a material saving in the number of points that require attention, the number of switches and connections, the important item of station floor space and the dividend-earning feature of efficiency.

The incandescent lamp is the key to the whole system of three-wire distribution. The limits to practical distribution areas, the per cent. of variation allowable in the pressure at mains, and the cost of the system in any particular case, depend directly on lamp qualities. The voltage of lamps is, perhaps, the most important single feature, since the cost of the copper for conductors decreases, and the radius of distribution increases as the square of the pressure at which lamps are operated, the load and per cent of loss being constant.

Until within the last two years the maximum pressure of commercial incandescent lamps has remained at about 110 volts. During more than a year back, however, manufacturers have regularly offered lamps of sixteen and larger candle powers for from 220 to 230 volts pressure. The voltage of practical lamps is thus doubled at a single step, the radius of transmission increased four times, and the area of distribution multiplied by sixteen, for a constant per cent. of loss.

The great advantages to the three-wire direct system of distribution from the doubled voltage of incandescent lamps are at once evident, and are being made available in new plants.

There are many details of construction and insulation to be modified before the 220-volt lamp can come into general use on the old three-wire systems, where 110-volt lamps are now operated, but the change will no doubt be made in time, to the benefit of central stations and the public. The improvements above noted in the three-wire system, and especially the higher voltages of incandescent lamps, seem to insure for it a tendency to displace all other systems of public distribution.

ALTERNATING-CURRENT ARC LIGHTING.*

BY R. FLEMING.

It was not until the extensive introduction of alternating systems for lighting by incandescent lamps that the demand for a commercially successful arc lamp suitable for use upon such systems spurred inventors to renewed activity. Many new forms of open arc lamps resulted, manufacturers in Europe and America vieing with each other to perfect their systems. They were all more or less failures, however, and I think I hear some of you saying, "It was not until the adoption of the enclosing globe that the alternating arc lamp was put on a practical footing," and that if the globe had been invented sooner we should have achieved success that much sooner. But, softly—we have, as a matter of fact, had the enclosing globe ready to our hands for many years, and that, too, in practically the identical shape and fulfilling all the requirements of to-day.

In English patent No. 1507 of 1880 to George G. Andre, we find illustrated and described an enclosing globe so constructed that the supply of air reaching the carbons may be regulated and controlled. Andre speaks of the device as being applicable to many forms of arc lamps, both alternating and direct. His first claim reads as follows:

"The mode herein described of supplying the carbon or other electric lamp electrode, in the interior of a closed vessel or lantern with a definite or regulated quantity of air for the purpose specified." Quite a large number of English patents for enclosing globes were granted between 1874 and 1881, but none of the others seem so clear as that of Andre. And he may, I think, be justly considered a true pioneer in the art, and as having revealed practically all that we find in modern practice.

In United States patent to G. W. Beardslee No. 265,737, October 10, 1882, we have a description of an enclosing globe, with somewhat narrow claims on special features, and showing a small globe instead of the large one of Andre. In United States patents to William Baxter, No. 306,998, October 21, 1884, and No. 288,157, November 6, 1883, is a description of a complete enclosed arc lamp.

This lamp was introduced commercially about 1884 and 1885, and came to the notice of the general public by reason of some lengthy debates at different electrical gatherings as to the effective candle power. My personal recollection is that the lamps were operated in many cases at rather high voltage, often as high as 65 or 70 volts, with the current at 10 amperes or less, and that the lights had a strong violet or blue tint which was objected to very strongly by many engineers.

In more recent years United States patents were issued to a number of inventors covering different arrangements of lamps using enclosing globes. I recall the following to Marks & Ranson, No. 520,966, June 5, 1884, and No. 521,936, June 20, 1896.

Having carefully reviewed these patents I will say that I am unable to find revealed therein anything which was not old in the art at the time they were issued unless it be the device described by one of their claims which seems to me inoperative. I have yet to hear that either Marks & Ranson or anyone else has succeeded in operating a constant potential enclosed arc lamp without having other resistance than that of the arc included in the circuit. Again, Marks & Ranson make a claim for the operation of an enclosed arc lamp at abnormal voltage. In view of the fact that arcs of widely varying voltage had been used prior to their time this claim would seem void for lack of novelty.

Coming now to a description of enclosed alternating arc lamps of more modern construction-lamps which we may consider commercially successful—we find quite a variety of designs, the principal points of difference in these designs being in the systems of control or regulation adopted. The general tendency, however, has been towards the use of electro-magnets of what is known as the solenoid type either double or single, that is, making use of a single solenoid with a straight core or two solenoids side by side with a U-shaped core. Stability of operation is attained in practically all of the different types by the introduction in series with the lamp of an inductive resistance or choke coil adapted to take up a greater or less portion of the total energy used for each lamp. In order to adapt the lamp for different frequencies the coils are most generally wound in such a manner that the number of turns can be varied and adjusted to suit the particular frequency desired, and in addition to this, provision is made for a slight change in the number of turns to adjust the lamp to any particular voltage upon which it is desired to operate. In some of the forms of lamps changes are also necessary in the regulating electro-magnet while in others a considerable change of frequency can be made without a change being required in the turns on the magnet, but in which a simple change in the adjustment of the mechanism fulfills all requirements.

In a type of lamp, recently introduced by the Western Electric Company, the use of the ordinary electro-magnet for arc regulation has been abandoned, and in its place an electro-magnetic device provided with an induction or inductive armature of non-magnetic material has been adopted. Movement of the carbons, to establish the arc and to afterward regulate it, as the carbons are burned away, is accomplished in this lamp by the application of the well-known principle of the repulsion of closed circuits by an alternating-current magnet.

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*Abstracted from paper read before the Northwestern Electrical Association.

In this lamp the regulating mechanism is provided with an induction armature formed of aluminum forming a closed circuit around the poles, this metal having been found preferable to copper or any other conductor, by reason of its great lightness and moderate cost. The armature has been so designed that the energy absorbed in it can be taken care of by direct radiation without permitting the temperature to rise beyond the danger point, and while it has been found practicable to run the temperature considerably higher than would be safe if any ordinary insulating material were used in connection with it, the temperature is still safely within bounds, and so far as the ohmic resistance of the armature is concerned the temperature variations within the limits of which it operates cause no appreciable trouble.

Among our Foreign Contemporaries

Charging for Wattess Currents.—Mr. Benischke of the General Electric Company of Berlin had advocated a system of charging for current, based on this principle, in a paper read at the last meeting of the German Union of Electrical Engineers, and reprinted some time ago in the "Elektrotechnische Zeitschrift," and his proposal was also advocated later by other writers, in French journals. He pointed out that to charge a proper price for alternating currents, it is necessary to charge to the consumer not only the watts consumed by him, but also a certain percentage of the "wattless power," as the cost of the power produced in an alternating current plant is not proportional to the watts, but depends also upon the power factor. As the safe limit of a machine depends upon the maximum permissible current and not on the power, all the machines of the plant, and also the line and the transformers, must be designed for a greater power than required by the real watts. It is therefore not more than just that this should be duly considered in determining the price of the proper to the consumer. Benischke proposed to make the consumer pay for a certain percentage of the wattless power and to lessen somewhat the price for the unit of power. He also showed that it is easy to modify a wattmeter so that a certain percentage of the apparent watts is registered as effective watts. This can be accomplished simply by giving to the voltage coil of a wattmeter, a certain self-inductance, so that there is a difference of phase. As a numerical instance he calculates the case in which the tangent of the difference of phase is made equal to 0.05. The wattmeter then indicates more than the true power; if the power factors are 1.00, 0.95, 0.9, 0.8, 0.7, 0.6, then the wattmeter measures 1.00, 1.016, 1.025, 1.0375, 1.05, 1.0665 times the true power respectively.

German Automobiles.—In Continental Europe, especially in France and Germany, automobiles are exciting much interest and a large new industry is growing up. In Paris there is in progress a long, well-conducted competitive test of automobile accumulators, and in Berlin there was recently an international motorcar exposition, which is the subject of an interesting and long illustrated article in a recent number of the "Elektrotechnische Zeitschrift." Although gasoline motor cars were in the majority, a great number of electric automobiles were also exhibited. In some of the automobiles exhibited, the whole of the driving machinery, motors, etc., are combined with the front wheels to form a complete driving unit in itself, so that any desired carriage body, whether for passengers or for package delivery, may be supported by it. As this driving machinery is the more expensive part of an automobile, this arrangement appears to save considerable cost, as a single driving truck may then be used with any one of a number of carriage or wagon bodies; it is like hitching a horse to any one of several carriages. The adjoining figure shows such a driving unit; it contains two motors of 2 h.p. each and the reduction is 16 to 1. No further description is given.

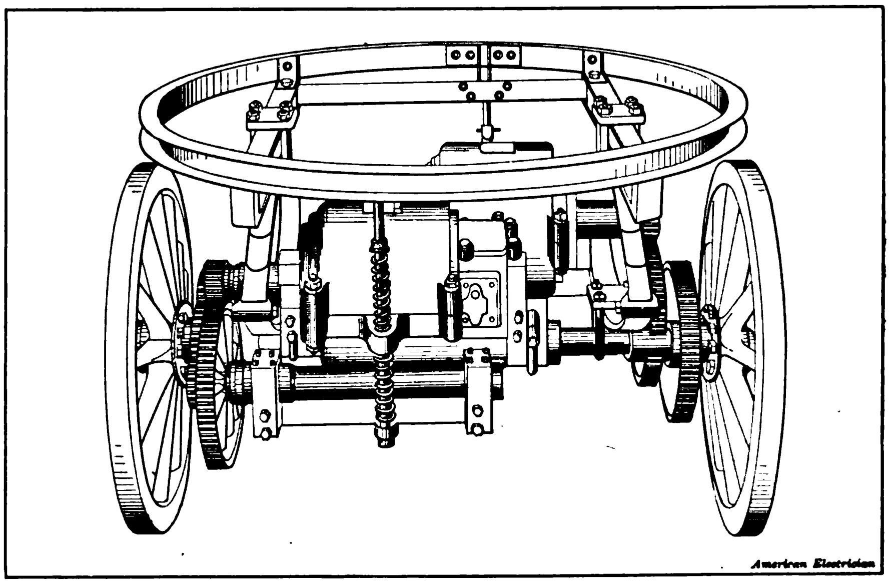

FIG. 1.—AN AUTOMOBILE RUNNING GEAR FOR INTERCHANGEABLE BODIES.

Alternating Current Arcs.—A description of the elaborate series of experiments made by Messrs. Duddell and Marchant, the first part of which was referred to in the American Electrician of June, has been concluded in the "London Electrician" and contains some further deductions of practical value to those working with alternating current arcs. They found that the stability of the arc, as an electrical phenomenon, is greatly increased by a large impressed e. m. f. in its circuit, and the necessity of this e. m. f. is greatest when the instantaneous value of the current is small, so as to reduce the time during which the arc is extinguished in each period. The time of the extinction is a very important quantity as the voltage required to relight the arc increases rapidly with the duration of the extinction. A high voltage may be impressed on the circuit by means of a self-induction in series with the arc, as this ensures a high voltage when the current vanishes; a self-induction of course has the advantage over a resistance in that it wastes no power, or at least very little, but it may affect the efficiency of the generator by causing the current to lag. In place of this self-induction an inductive alternator or a transformer will aid in giving stability; if, besides this, the machine or transformer has a very drooping characteristic, then sufficient stability may be obtained with the addition of outside inductance or resistance. The reduction of the frequency reduces the stability, and the lowest limit to the frequency is higher with solid than with cored carbons, but high frequency arcs are less efficient than low ones. The nature of the carbons has a great effect on the stability; arcs between cored or between solid and cored carbons being very stable, while those between solid carbons are much less so. The addition of a compound of sodium or potassium is very effective in improving the stability, but it lowers the voltage at which the arc burns and this makes it less efficient.

Eddy Current Brake for Tramways.—A recent number of the "Elektrotechnische Zeitschrift" contains a description of a new brake of some interest, in which electric and mechanical methods of braking are combined. It has been introduced in practice by the Helios Co. and is said to have proved very satisfactory. As long as the speed of the car is high, the braking is done by eddy currents alone; the mechanical braking comes into operation when the speed has decreased so much that the eddy currents are too weak for effective braking. The brake consists of two main parts, a set of electro-magnets, and an iron armature, on which the magnets act. The set of electro-magnets comprises six alternate poles arranged in a circle around the axle of the car and fixed on the frame of the car. The iron armature has the form of a ring around the axle opposite to the magnet poles, for closing the magnetic circuits, and is fixed on the axle of the car and rotates with it; it is also capable of being moved along the axle. By a special mechanical device of considerable ingenuity, which is based on the action of the centrifugal forces, and works automatically, the armature is moved nearer to the magnets when the speed decreases, and is farther from the magnets when it increases. As the forces of the poles always tend to attract the armature, their action is in the same direction as that of the mechanical device for decreasing speed and opposes it for increasing speeds. In the first tramway line on which this brake has been used, the cars had only one motor; the second axle was therefore provided with the brake. During the time of braking, the current for the electro-magnets was supplied from the motor, which was then connected as a generator so that there was a braking action on both axles. When the braking begins, the speed of the car is high, hence the e.m.f. of the generator is great and also the current exciting the electro-magnets. For decreasing speeds the exciting current also diminishes, but at the same time the armature is moved nearer to the poles, so that the reluctance of the magnetic circuits is diminished and the braking action is not lowered. Ultimately, when the speed is low and the eddy currents small, the armature is pressed against the magnet poles, so that there is then mechanical braking also.

Measuring Instruments in High Tension Plants.—In many of the high-voltage transmission plants in which the high voltage is generated directly by the alternators, thus avoiding the use of step-up transformers, there is difficulty with the measuring instruments, especially with the voltmeter. Ordinary magnetic voltmeters or hot wire instruments with resistances in series cannot be used on account of the large consumption of energy and the high price and great space of the resistances. Electrostatic voltmeters are not exact enough and are too sensitive to mechanical shocks. In many of these cases special transformers are therefore used for feeding the instruments; they are, however, rather expensive, and even if carefully made, they are always a weak point of the plant. In an interesting article in the "Elektrotechnische Zeitschrift," Mr. Schueler describes the following method which is used in all high-voltage plants installed by Lahmeyer & Co. All instruments, voltmeters, ammeters, wattmeters, energy meters, and phase lamps, are operated at low voltage in such a way that they are not in conducting connection with the high-tension generated in the machines, and they may therefore be touched without danger. This is accomplished by connecting all the instruments to only a part of the armature windings, which is not in direct connection with the rest, but is connected with the primary winding of a transformer, the secondary of which is connected in series with the balance of the armature winding. If the transforming ratio of this transformer is one to one, the current flowing through the ammeter is nearly exactly equal to the armature current of the machine. In the practical application the number of these windings which are separated from the rest is important. For slow-speed machines with many poles, the simplest method is to use a whole armature coil, as in the adjoining Fig. 2. For a single-phase alternator of 100 kw., 10,000 volts, 50 periods and 90 r.p.m., the e.m.f. of one coil is 150 volts, which is very convenient for measurements. As the armature current of this machine is 10 amperes, the transformer is to be built for 1.5 kw. It will be cheaper and less dangerous than a measuring step-down transformer for decreasing the voltage from 10,000 to 150 volts. The connections for Y-connected three-phase machines can be made similarly, as illustrated in Fig. 3, the center of the Y being the measured coils delivering their power to the rest of the circuit through the Y-connected transformer shown in the upper part of the diagram. For high-speed machines with few poles it is not possible to separate a whole coil for the measuring current, as the voltage would be too high and the transformer would have to be built for a too great a power. In this case the armature coil is divided into two parts, one of which is used for measuring the current.

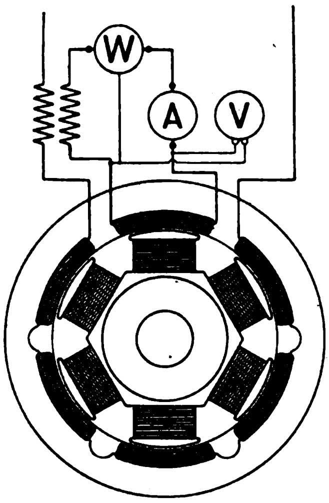

FIG. 2.—A NOVEL CONNECTION OF INSTRUMENTS TO HIGH-TENSION MACHINES.

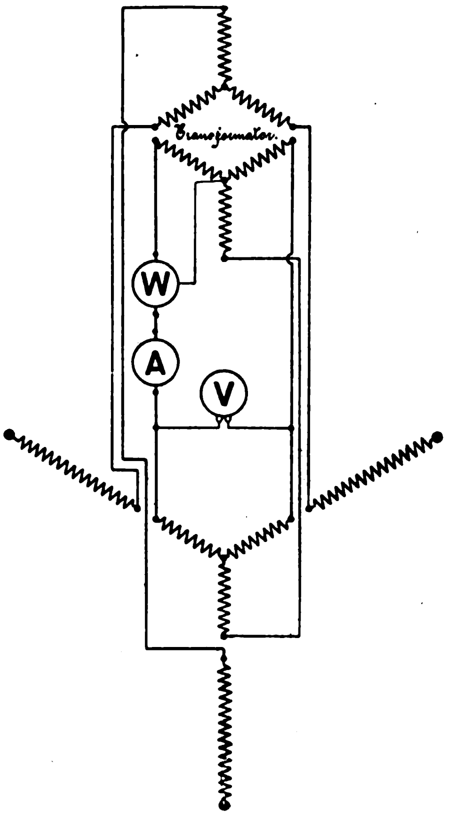

FIG. 3.—THE CONNECTION OF INSTRUMENTS TO HIGH-TENSION THREE-PHASE ALTERNATORS.

Automobile Accumulators.—During the past summer competitive tests of automobile accumulators were held in Paris, under the direction of the Automobile Club of France. In the terms of the competition each competitor had to submit five cells, the total weight of which in the box was not to exceed 242 lbs.; the capacity had to be 120 ampere-hours; the accumulators were disqualified when the voltage fell below 1.7 volts per cell. The discharge was intentionally made irregular in order to approximate ordinary automobile practice, so that the results may be regarded as indicating in how far the existing accumulators of to-day, meet the practical requirements for automobile work. In "L'Electricien" Mr. Bainville has published a series of articles in which he gives the results of these tests in tables showing the behavior of the batteries from month to month. In the last article, in which he deals with the test during October, he also gives a brief summary. The chief result is that in October the batteries which had proved satisfactory so far, failed. In fact, at the end of October all the batteries which had entered the tests at the beginning of the competition, had either failed entirely, or had been withdrawn from the competition several times. The only battery which survived had not entered the test until after the eighteenth discharge. He draws the conclusions that for automobile work the life of the accumulators at present in the market is not more than six months, and that after this period rather expensive repairs become necessary. He calls attention to the fact that these results were obtained with the best types of the accumulators of the present time, of strong construction, of a capacity relatively high for the required rate of discharge, and of considerable weight. He remarks that perhaps the life of some of the batteries tested could have been prolonged somewhat, if the manufacturers would have taken better care of them during the test, but this is only hypothetical. In fact, some of the other batteries could stand the tests only as long as they were being taken care of by the manufacturers to an extent which is impossible in ordinary practice.

Engraving by Electricity.—In a recent number of the "Zeitschrift fuer Elektrochemie" there is an interesting article by Dr. Langbein on a process of engraving dies by electrolytic etching, which was first mentioned in a preliminary note two years ago and has since been worked out carefully so that it is now ready to be used extensively by a recently formed German company. A negative cast of the original is made of plaster of Paris or any other suitable porous material, and is saturated with the electrolyte; this cast is then connected as a whole with the negative pole of an electric source. It is then pressed slightly against the metal plate to be etched, which is connected with the positive pole. By this contact the circuit is closed, so that at the points where the negative cast touches the metal plate, the metal of the latter is dissolved, thus forming the exact counterpart of the negative cast. The contact should be made only for a moment, the cast being then removed and the metal plate brushed off in order to remove the insoluble materials contained in the metal; contact is then made again and the process repeated. As it is of the utmost importance that at the successive contacts exactly the same points are in contact with the metal, this part of the process is to be accomplished by an automatically operating machine; the brushing off is also done automatically by means of a quickly rotating brush. To etch a steel plate to a depth of 40 mils, it must be touched with the negative about 600 to 700 times, each time for 12 seconds, 4 to 5 hours being required for the whole process. The best electrolyte for etching steel is a solution of 10 per cent of chloride of ammonium, with some hydrochloric acid. The best current is 1.3 amperes per square inch, at 8 to 12 volts. The voltage must be regulated; it has to be smaller at the beginning of the process, when only the highest points of the negative cast are touching the plate. Great difficulty was experienced in getting a good quality of plaster, as it must be hard and its porosity should be neither too great nor too small.

Difference of Potential and Electromotive force.—Attention has frequently been called to the necessity of distinguishing between an electromotive force and a difference of potential, for if this is not done, confusion is likely to arise, particularly in the minds of those not thoroughly familiar with the theories involved. In such cases as the difference between the e.m.f. and the difference of potential at the terminals of a dynamo or battery, no confusion can arise as the difference between the two terms is well understood in that case, but there are other cases in which the difference is not as evident, and these sometimes lead to results which at first seem to be somewhat puzzling. To illustrate this, Mr. H. Teege in the "Electrotechnische Zeitschrift" calls attention to a case which, though not new, is of interest as it seems to be paradoxical, at first sight at least. The case is one in which no difference of potential can be detected between two points of a closed circuit, although a current is flowing. The arrangement is that shown in the accompanying figure, which is part of section and part full view, N being a cylindrical north pole, the mate to which is the single south pole, S S, which is in the form of a cylinder encircling the north pole and in this drawing is shown in cross-section; a perfectly uniform field is therefore produced in the annular space, A B, between the two poles; such a field is sometimes called a unipolar one, to distinguish it from the bipolar fields in the usual dynamo. Through this field a ring of copper, as shown, is moved say to the right, the motion being in the direction of the axis, and from the well-known laws of induction a current will then flow through that ring as long as it is being moved through the field. If now a galvanometer is applied to two points of that ring as shown, no difference of potential will be indicated although the current is flowing; it is assumed of course that the leads to the galvanometer do not cut lines of force. He thereby shows that difference of potential and e.m.f. are two entirely different things, although in many cases they are very nearly the same. Another similar case which he cites is that of an induction coil which is short-circuited; if any two points of the coil are connected with a galvanometer and a magnet is suddenly moved into or out of the coil, there would scarcely be a deflection in the galvanometer, while if the coil is not short-circuited a large deflection would be produced. A simple explanation of the above phenomenon is that in each small portion of that ring, an e.m.f. is generated, but as the ring is short-circuited in itself, just as much of the e.m.f. as is generated in each unit of length, is consumed, as it were in the form of a loss of potential due to that current traveling through that small part of the length of the conductor; or in popular terms, the e.m.f. is used up as fast as it is produced and in that part of the conductor where it is generated. If, for instance, in the figure shown, part of the ring had a higher resistance than another part, the galvanometer would show a difference of potential; the same would be true if the ring were cut, and the ends closed through a resistance external to the circuit. Another explanation of the phenomenon is given in the next issue of that journal by Rosenberg, who states that the case is similar to that of a short-circuited alternating-current generator. The whole circuit must be considered as made up of elements which generate and at the same time consume volts, or more correctly speaking, energy. There is a well-known law that the algebraic sum of e.m.fs. generated in a circuit and the losses of the difference of potential due to resistance or impedance, must be zero; or in the case of alternating currents the geometric sum must be zero; this law is true not only for the circuit as a whole, but in the case under consideration, it is true also of each element of the circuit.

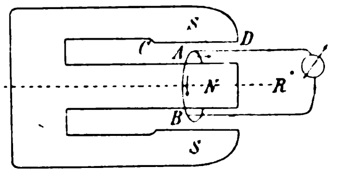

FIG 4.—A CASE OF ELECTROMOTIVE FORCE WITHOUT DIFFERENCE OF POTENTIAL.

A Frequency Meter.—It is sometimes desired to measure the frequency of an alternating current, when no access can be had to the machine. A very simple form of an instrument for doing this is described by Mr. Stockhardt in a recent issue of the "Elektrotechnische Zeitschrift." The main part is a wrought-iron tuning fork, the prongs of which are provided with adjustable weights to vary the frequency of the vibrations. Between the ends of the prongs there is a coil with a core of soft iron. This coil is connected to the circuit through high resistances, so that it is possible to use the instrument with circuits of 80 to 140 volts, like a voltmeter. The adjustable weights are pressed against the prongs by means of springs, and can be moved by two wires leading around two drums. To enable the operator to use only one hand, the right hand drum is braked, while the left one contains a watch spring which draws both weights back when the braked drum is turned in this direction. In this way it is easy to adjust for the maximum of sound, which occurs when the frequency of the current in the coil is a multiple of that of the oscillations of the note. As this is the case for any multiple, it is necessary to be cautious; the approximate value of the frequency must be known in advance. In the instrument as actually constructed, the adjustable weights are moved along a fixed, empirically determined scale, which gives the frequency of the current directly, when a half period of the current is equal to three oscillations of the fork. Hence the frequency can be read directly from the scale, if it is between 90 and 120. The results of a test are given in a table and show that the instrument enables very sharp readings to be taken, the errors being below one-quarter of a per cent.

Leblanc's Amortisseur.—In his recent presidential address to the English Institution of Electrical Engineers, published in the English electrical journals, Prof. Silvanus P. Thompson called attention to a device of Mr. Leblanc, called an "amortisseur," and said that he considered this invention to be one of the most important of recent years. It serves the purpose of preventing the hunting of alternators which are connected in parallel, and consists of a simple and substantial squirrel cage of copper embedded in the pole pieces of the field magnets, each pole being perforated with six slots to receive six stout copper rods, the whole of which are short circuited together by two external rings of copper. In a long article in a recent issue of "Elektrotechnische Zeitschrift." Dr. Benischke gives the following explanation of the action of this device. He points out that the hunting of alternators connected in parallel is a phenomenon of interference or superposition. Every direct-coupled machine has a lack of uniformity in the speed during a revolution, and this variable speed of rotation may be considered to be separated into a rotation of uniform speed and a superposed oscillation, which latter is analogous to the oscillation of a physical pendulum; the period of this superposed oscillation is proportional to the impulses caused by the motion of the piston of the engine. The amplitude of this superposed oscillation is damped in very effectively by Leblanc's amortisseur, the action being quite analogous to that in the old experiment with a pendulum consisting of a copper plate, the oscillations of which are damped by eddy currents induced in it when it is cuts through a magnetic field. Prof. Thompson referred in his address to the following highly interesting experiment made in the lighting station of the town of St. Ouen. Two alternators of 250 kw. each, provided with amortisseurs, direct driven at 67 r.p.m. by two horizontal, compound engines and separately excited, were synchronized and connected in parallel in the usual way. While thus running, the excitation was suddenly stopped in the field magnets of one alternator, after which the steam was cut off from the engine driving the other alternator, which remained excited. Both machines continued to turn, the unexcited alternator continuing the supply, furnishing current for the lighting circuit, and also supplying enough current to continue to drive the other machine and its engine. This test was repeated many times. The amortisseur has also been applied to the 600-kw. alternators in the sector of the Champs Elysees in Paris, and, as we see from a recent series of articles of Mr. Leblanc in "L'Eclairage Electrique," it is used in a large degree also by the General Electric Company of Berlin. He quotes an instance of two large Oerlikon alternators of 1000 h.p. which refused to work in parallel, until they were provided with amortisseurs to check the hunting by braking, so to speak, the movement of the field across the pole faces.

End Connections on Armatures.—It is a common practice now to have the end connections of armature coils, that is, those parts of the winding which are at the ends of the armature and not in the field, formed like a flat letter V, with the parts bent into curves, thus forming a regular rosette. This is the usual method in form-wound coils, which are now so often used, and also in cases in which bars are used on armatures, the ends being connected by copper strips bent as above described. It will readily be seen that in such end connections considerable depends on the shape into which they are bent, for if this is not correct, much more space will be occupied by the rosette, than is really necessary. Mr. Girault, in "L'Industrie Electrique," discusses mathematically the question of the exact theoretical curve to which these connections should be bent. The problem is, to bend them in such a way that the distance between two neighboring parallel connections, measured normally to the curve, should always be the same in all parts, so as to allow for the same thickness of insulation. The curve which brings about this result he shows to be what is known as an evolute of a circle, that is, it is the curve described by a point on a string which is being unwrapped from the circumference of a circle, as shown in the adjoining figure, in which a, b, c, d is the curve described by the end of the string while it is being unwrapped. It will readily be seen that the curves made by two points on that string will always be equally distant, as shown in the figure. The circle there shown is of course the inside circle, that is, the one showing where the inside ends of these connections must terminate; the outer ends of these curves beyond d and d' are the points where these end connections are connected to the armature bars. Having given a drawing of the armature, and the smallest inside circle, the curves are readily drawn in with a string and a disc. In practice, however, he says it will generally be found that the exact curve cannot be used, owing presumably to the fact that the inner circle cannot always be made as small as the theoretically correct conditions would require, and in such cases he suggests drawing one curve from the point on the outside of the armature inward, and another from the proper point on the inner circle, toward the outer one, this point being at the middle of the angle subtended by the two bars of the coil; the best curve is then sketched in between these two so as to conform as nearly as possible to both of them. Those interested in the mathematical calculations involved will find them in the issue of November 25 of that journal, which also contains a table of convenient values for facilitating such calculations.

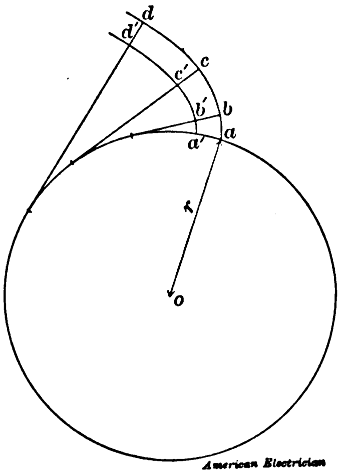

FIG. 5.—THE EVOLUTE OF A CIRCLE.

Failures of Alternating-Current Cables.—When alternating-current transmission first began to be used it was found that in switching in and out parts of the network of leads formed of concentric cables, there was danger of a discharge occurring between the outer conductor and the lead armor. Such discharges can be prevented by a rule which is not new but is worth repeating, and which is, that when the current is first switched on to parts of a network of circuits, the outer conductor should be connected before the inner is, while in disconnecting, the inner conductor should be disconnected before the outer. Mr. Kapp in a recent number of the "Elektrotechnische Zeitschrift" discusses these questions analytically and calls attention to another case of break-downs caused by the inner conductor coming in contact with the earth, the result of which is usually quite serious, being generally accompanied by other break-downs at other points; such cases have been noticed only in complex networks of concentric cables but not in those in which only a single transformer is used. He comes to the conclusion that the wires in such cases can be protected only by earthing the outer conductor. On account of disturbances which would thereby be produced in neighboring telephone circuits, such connection should be made at one point only, but this is sufficient when no fuses are used in the outer conductor. An inductionless resistance may be inserted in the earth connection so that the current, when the inner conductor becomes grounded, is not greater than that necessary to blow the fuse of the inner conductor. When twisted cables are used there is no outer conductor and this method cannot be applied, but the danger is then much less, as such cables have a much smaller capacity. The danger is increased by having small iron and copper losses in the transformer, and much more so by too great a current at no load and by a large inductive voltage drop; transformers should therefore be constructed with this in mind. When twisted cables are used, they should be fused at both ends, the fuses at the remote end being smaller than those at the central station ends; moreover, the transformers for complex networks should not be too small. No fuse should be used with the outer conductor when concentric cables are used, but in complex networks it should be connected to earth through a resistance. The question of earthing one of the mains of alternating-current circuits, is also discussed briefly in an editorial note in the London "Electrical Engineer." The advantage of earthing one conductor, when the voltage is high, is said to be so great that this method has been adopted in practically all of the important electric lighting stations in England in which such alternating currents are used. When the wires are in the form of concentric cables, it is the outer conductor which is always the one to be connected to earth; the objection to it is that a single fault on the inner conductor then practically short-circuits the system, but it is thought that this objection is more than overcome by the advantages over the case in which an attempt is made to keep both poles insulated. In the latter case, that one of the two leads which has the lowest insulation resistance will tend to keep at the earth potential and a ground on the inner conductor then immediately strains the insulation of the other, so that when a break-down occurs both of the wires are disabled; this case recently occurred at Hastings. When one conductor is permanently earthed another advantage is pointed out, which is that the voltage set up by resonance effects is not likely to be quite as destructive as when both wires are insulated.

Leading and Lagging Currents.—A recent number of the London "Electrical Engineer" contains descriptions of several practical methods for finding whether the current in a single-phase alternating-current circuit is leading the e.m.f. or lagging behind it. A very simple method, due to Prof. Silvanus Thompson, can be used when it is possible to close and break the circuit, and when the e.m.f. is sufficiently high. If there is a spark on closing the circuit, and none on breaking it, then the current is leading the e.m.f. Conversely, if there is a spark on breaking the current, then the current is either lagging behind the e.m.f. or is in phase with it. In many cases, however, it may not be possible or convenient to disturb the supply by opening the circuit and then other less simple methods must be resorted to. One way is to plot the curves of the current and the e.m.f. by a Joubert instantaneous contact ring or other similar device, but this requires time and special apparatus. The following is a method requiring no special apparatus. Connect an alternating-current voltmeter across the mains and an alternating-current ammeter in one main and in series with it an adjustable induction coil, as shown in the diagram, Fig. 6. If the current is leading and the self induction of the coil is gradually increased, beginning with a very low value, then the negative (capacity) reactance of the line will be gradually overcome by the increasing reactance of the induction coil. Therefore, if readings of the ammeter and the voltmeter are taken and the impedance is calculated by dividing the volts by the amperes, the impedance will first diminish to a minimum (the effective resistance of the line) and then increase again. If, however, the current is lagging, then the gradually increased reactance of the induction coil will be added to the reactance of the line, and if the impedance is determined in the same way as before, it will always increase. As adjustable induction coil, an ordinary coil of wire may be used which has a very small coefficient of self-induction, if there is no iron in the magnetic circuit; the self induction may then be increased by placing strips of iron into the magnetic circuit. As will be seen, the main point of distinction in this test is that, for a leading current the impedance first decreases; but it might be added that this occurs only when the coefficient of self induction of the coil of wire without iron, is so low that its induction reactance is smaller than the capacity reactance of the circuit.

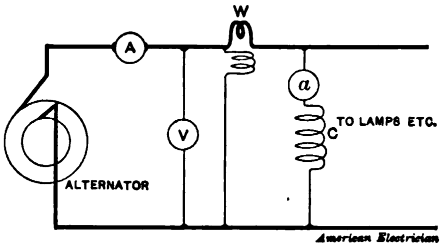

FIG 6.—CONNECTIONS FOR MEASURING LEADING AND LAGGING CURRENTS

Some Recent Electrical Patents.

An Underload Circuit Breaker.—For use particularly with storage batteries where it becomes desirable to cut off the battery if its charging current diminishes, Mr. W. M. Scott has patented a special form of underload I. T. E. circuit breaker, embodying the new laminated wedge contact. The breaker was illustrated in the American Electrician of July, 1899, page 363. Fig. 1 is reproduced from the patent. The laminated leaves, 4, of the main contact are mounted on a clamp which is movable on guide rods so that the leaves may be forced against the wedges, 2 and 3. To prevent any burning of these delicate leaves even with the small current under which an underload breaker opens, a little secondary contact is provided in the rod, 22, which enters between the clips or jaws, 23. There is no trigger to this circuit breaker, the contacts being held in the closed position by the armature, 19, which is held up to the pole pieces, 13, by the current in the coil in series with the main circuit. If this current weakens below a certain amount a spring enclosed within a tube not shown forces the armature away from the pole pieces and opens the circuit. The secondary or supplementary contact is opened by a spring which gives it a quick break. Patent No. 636,458.

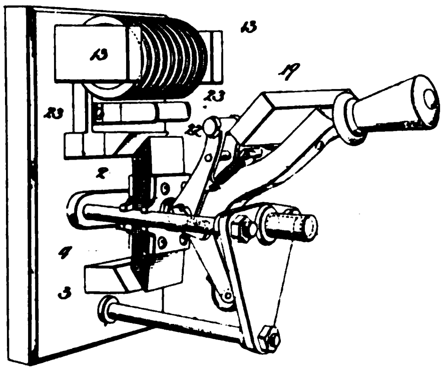

FIG. 1.—AN UNDERLOAD CIRCUIT BREAKER.

A Well-Developed Scheme for Insulating Transformer Windings.—In winding the coils of core-type transformers, the end turns of each layer are liable—especially if wound under considerable tension—to slip down in the form on which the coils are wound and come in contact with turns from which they should be three or four layers removed. It is customary in winding coils having a considerable difference of potential per turn—as have alternating-current coils such as those of transformers—to insert a sheet of some insulating material, such as bond paper, between the layers, since the voltage between one layer and the next is much greater than the voltage between adjacent turns of one layer. This practice is, however, not thoroughly consistent as in one end of the coil the wire runs from one layer to the other so that these two layers have at this end only the difference of potential set up in one turn, while at the other end of the coil there is a difference of potential between the same two layers equal to twice the average difference of potential between them. Messrs. J. W. Packard and H. W. Wiswell of the New York & Ohio Company have patented a means of inserting the insulating sheets between the layers so as to prevent the end turns from slipping down as well as to put the insulating material where it will do the most good. As the cut, Fig. 3, clearly shows, the paper or other fibrous material used as extra insulation between the turns is laid in in such a way as to enclose several turns of two adjacent layers at the end at which there is a small difference of potential between these layers. This enclosure, fastened as it is to the sheet running the whole length of the coil, prevents the layers from getting out of place. Patent No. 640,314.

A Knock-Down Junction Box.—An improvement in the design and construction of junction boxes which makes them readily collapsible for transportation and easily changeable to different sizes and shapes is the invention of Mr. T. J. Murphy, illustrated in Fig. 2. The improved form consists of a back plate of slate or enamelled metal on which may be screwed corner brackets holding the usual slate walls of the inner compartment and the insulating gutter. By carrying in stock strips of slate of various lengths and back plates of various dimensions the boxes can be made up as required. The claims on this improvement are broad, the first one reading: "A junction box comprising a base, a collapsible outer box and a collapsible inner box, substantially as set forth." Patent No. 640,482.

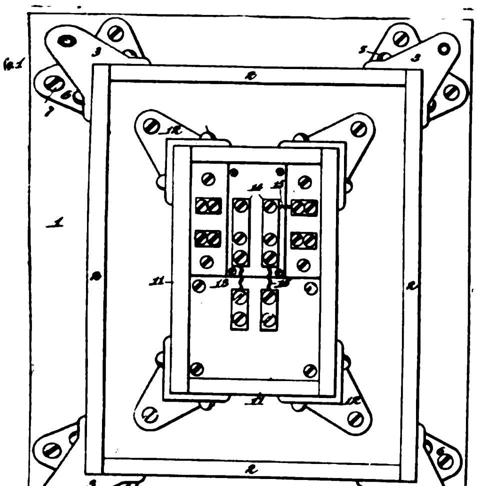
FIG. 2.—A KNOCK-DOWN JUNCTION BOX.

An Ingenious Booster Connection for Three-Wire Storage Batteries.—In the work of the Electric Storage Battery Company on three-wire lighting systems in this country it is customary to obtain regulation by the use of end-cell switches instead of boosters, although the latter are commonly used in street-railway and two-wire isolated plant work. The neutral of the distributing network is permanently connected to the middle of the battery, the last few positive and the last few negative cells being made end cells. If a booster were used with such an arrangement it would necessarily contain two completely separate generators, one for the positive and one for the negative end of the battery. Partly on account of this added complexity three-wire batteries are charged without boosters, but by running one pair of the main generators at a higher voltage than the rest, isolating these generators on a set of "charging" bus bars and connecting these into the battery through charging end-cell switches. Mr. Albert S. Hubbard has patented and assigned to the Gould Storage Battery Company of New York City, a novel means of connecting up the system so that it need contain only one machine, and yet the battery can be used to supply a three-wire system with independent regulation by means of end-cell switches on both sides of the neutral. The connections are shown in Fig. 4. In this case the regulating cells which take the place of the end cells (the name "end cell" no longer applying in this case) are shown in the center connected to contacts 9 and 9′ of the switches 10 and 10′ of the usual end-cell type. These switches regulate the number of cells connected to the outgoing feeders of the network. All charging current is received from the dynamos through the ends of the battery.

The booster, 13, charges those cells on either or both sides of the system, which are not charging from the three-wire mains, the number in circuit being regulated by the position of the second set of end-cell switches, 15 and 15′ these switches being moved back as the cells nearest the center ends become charged.

When the e.m.f. of the positive battery equals the e.m.f. of the negative, the batteries charge in series across the outer wires of the system.

Should it be desired to charge one battery at a higher rate, the regulating cell switch connected to that battery is moved back, cutting out one or more cells until the desired rate is obtained, the neutral connection in that case carrying the excess current. Patent No. 640,565.

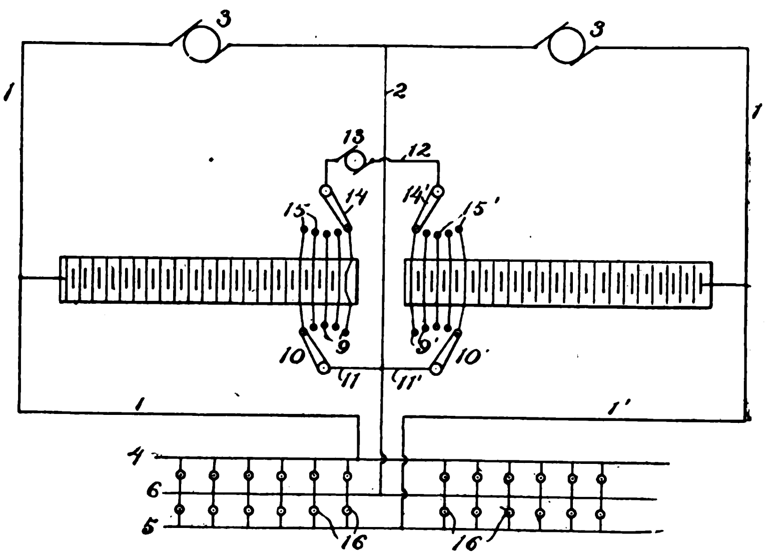

FIG. 4.—A BOOSTER FOR THREE-WIRE BATTERIES.

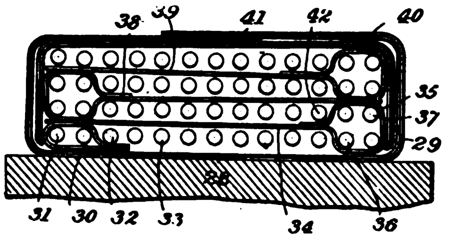

FIG. 3—THE INSULATION OF TRANSFORMER WINDINGS.

Improvements in the Nernst Lamp.—The chief difficulties which prevent the rapid introduction of the Nernst lamp may be said to be the high temperature of the magnesia pencil, which causes burning of the contacts, the trouble of starting by means of some auxiliary heating device, and difficulties of regulation due to the fact that the material used falls in resistance rapidly as the temperature rises, tending to take more and more current, which tends to give a still lower resistance and finally burns it out. Prof. R. A. Fessenden of the Western University of Pennsylvania has recently taken out a number of patents claiming arrangements for overcoming these difficulties. For the first he proposes a pencil of the usual material, thoria, magnesia or kaolin, with ends formed of a composition which becomes a conductor at a lower temperature than the material of the center. The specifications state that such a material may be found in a mixture of thoria and magnesium chloride, or magnesia and magnesium chloride, or a mixture of thoria and magnesia. The end portions may be so prepared that the proportion of the material which becomes a conductor increases gradually from the point of junction toward the end. A mixture consisting of 10 per cent. of chloride of magnesium and 90 per cent. of magnesia is claimed to give very good results with a body or center portion formed of magnesia. By means of this material at the ends of the pencil these ends do not become as highly heated as the center, and terminals formed of nickel or an alloy of nickel and iron, may be employed instead of expensive terminals of platinum, which are necessary when the whole length of the pencil becomes conductive only at very high pressures. In another patent the same inventor proposes the use of graphite for the ends, this graphite being able to withstand the high temperature of the pencil itself, but serving to insulate this high temperature from the metal terminals. In other patents the professor describes an unusual means of obtaining the preliminary heating from the electrical circuit. This means is shown in the section of a lamp, Fig. 5. Here the conducting and illuminating rod itself is shown at 4, mounted on metal terminals which are arranged for rotation, and geared to a wheel which, in turn, rotates a screw in the upper part of the lamp. This screw carries a block of graphite which rests upon the rod, 4, and is moved along it from end to end when the screw is turned. This movement, combined with the rotation of the rod, 4, leaves a coating of graphite which carries current from one metal terminal to the other as soon as a circuit is made through the conductors. This current heats the rod to incandescence, when the rod itself becomes conductive and burns the graphite off from its surface. The same illustration shows a means of regulating the current and preventing the reduced resistance of the rod under high temperatures from causing an increased flow of current, which, in turn, still further reduces the resistance and burns the lamp out. The regulating mechanism is shown in the upper part of the lamp and consists of a resistance in series with the magnesia rod, this regulating material being of a character which will suddenly increase in resistance when more than the proper current flows. The material may consist of lead enclosed in a glass tube. When the lead begins to soften under the heat its resistance rises rapidly, preventing any further increase of current. One of the patents also mentions the use of manganese peroxide for rubbing over the pencil and forming a starting path, the value of this material being the fact that it becomes non-conductive at high temperatures. This being the case, it would appear to be possible to put a core of manganese peroxide within the magnesia rod, the manganese peroxide serving to start the lamp without any rubbing mechanism whatever and transferring the current to the magnesia as soon as both become heated. This would also make the current flow through the lamp more stable, the manganese peroxide taking less current as the magnesia took more, and vice versa. Patents Nos. 638,837, 638,838, 638,839, 638,840 and 639,161.

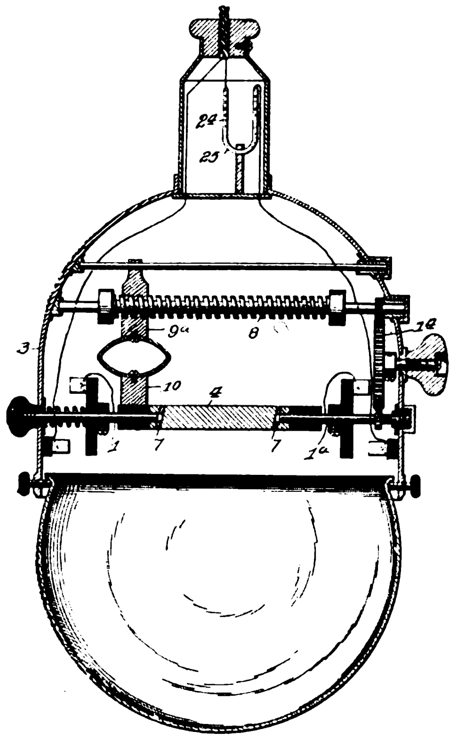

FIG. 5.—THE NERNST LAMP.

NOTES.

The Annual Meeting of the National Electric Light Association. — The dates decided upon for the twenty-third convention of the National Electric Light Association are the 22d, 23d and 24th of May, 1900. The meeting will be held in Chicago.

The Purchase of two Independent Telephone Systems by a Bell Company.—The Michigan Telephone Company, now part of the Erie Telegraph & Telephone Company, has acquired through purchase of stock a controlling interest in the Detroit Telephone Company and the new State Telephone Company. The two latter companies operate about 6000 miles of independent long-distance lines and have about 10,000 telephone subscribers in Detroit and neighboring cities and towns in the State of Michigan. As is well known, these two companies were pioneers in the independent telephone movement and their absorption by Bell interests is therefore quite an event in the struggle of the independents.

The Reorganization of the Stanley Company.—The Stanley Electric Manufacturing Company was incorporated under the laws of the State of New Jersey on January 5th, with an authorized capitalization of $2,000,000. The incorporators named are connected with the John A. Roebling's Sons Company, a large interest in the Stanley Company having been obtained by Mr. Ferdinand Roebling some time before the recent proposed consolidation with the Sprague Company. It is semi-officially announced that the Roeblings, with Gov. Crane of Massachusetts, and several large users of electrical apparatus, will provide the full amount of capital stock required for the building of large shops at Pittsfield and greatly extending the business of the company.

The Death of S. Dana Greene.—On the afternoon of Jan. 8, Lieut. S. Dana Greene, Sales Manager of the General Electric Company, and Mrs. Greene, were drowned while skating on the Mohawk River, near Schenectady. Mr. Greene was 35 years old and was the son of the late Commodore S. Dana Greene of the U. S. Navy. He was educated at the Naval Academy at Annapolis, but after a short term of sea duty had been actively connected with electrical manufacturing houses, first with the Sprague railway motor interests, then with the Edison General Electric Company, and finally with the General Electric Company, of which he was, at the time of his death, General Sales Manager. During the recent war with Spain Mr. Greene was executive officer of the auxiliary cruiser Yankee. Since the close of the war he had been serving on the staff of Gov. Roosevelt of New York State with the rank of Lieut. Commander. Mr. Greene was married in June, 1896, to Miss Cornelia Chandler, a daughter of Admiral Chandler. As noted above, his wife died with him. No children survive them.

The Convention of the North Western Electrical Association. — The eighth annual meeting of the Northwestern Electrical Association was held at the Hotel Pfister, Milwaukee, Wis., on Wednesday, Thursday and Friday, January 17, 18 and 19. The following papers were read: "The Modern Development of Alternating-Current Series Arc Lamps," by R. Fleming, Lynn, Mass.; "Alternating-Current Phenomena," by Prof. D. C. Jackson, Madison, Wis.; "A Life Test of Incandescent Lamps," by Prof. Geo. D. Shepardson, Minneapolis, Minn.; "Central Station Economies," by H. W. Frund, Vincennes, Ind.; "Induction and Direct-Current Motors," by R. D. Mershon, New York; "Relative Efficiency and Desirability of Various Types of Engines on Central Station Loads," by Prof. A. W. Richter, Madison, Wis.; "Combination of Electric Lighting and Hot-Water Heating Plants," by W. H. Schott, Chicago, Ill. The following officers were elected for the coming year. President, Mr. Pliny Norcross, Janesville, Wis.; First Vice-President, Mr. H. W. Frund, Vincennes, Ind.; Second Vice-President, H. J. Gillie, St. Paul, Minn.; Secretary and Treasurer, Thos. R. Mercein, Milwaukee, Wis. Directors, Messrs. Schott, Westover and Innes. The association decided to hold a summer meeting during the present year at Waupaca, Wis., the date to be fixed later. It was proposed to hold the regular annual meeting in future at other points than Milwaukee. The adoption of this proposal will be determined by letter ballot.

The New York Rapid Transit Road.—Bids were opened on January 15th for the construction and operation of the underground rapid transit road in New York City. Two bids were received, one proposing to build the road for $35,000,000, and the other for $39,300,000. The former, which was submitted by John D. McDonald, was accepted on Jan. 16th. Mr. McDonald is a well-known contractor, having built the famous Baltimore & Ohio tunnel in Baltimore and now building the Jerome Park reservoir for New York City. The contract is one of the largest, if not the largest, single contract ever let. It calls not only for the construction of the whole tunnel for the sum named, but for its equipment and operation for 50 years, at a rental sufficient to pay the 3½ per cent. interest on the bonds which the city will issue to provide funds for the construction, and one per cent. additional for a sinking fund. It is expected that a considerable premium can be obtained on these bonds, making the total rental about $350,000 per year. The city reserves the option to delay the construction of all but the first section. The contract requires that the contractor shall make a deposit of cash or securities to the value of $1,000,000, and file a bond of $5,000,000 for the construction and equipment in addition to a continuing bond of $1,000,000 during the entire time of operation. The work is to be begun within thirty days from the time of executing the contract. The contractor believes that the tunnel can be built in three years' time.

Another Hydraulic and Electrical Transmission Scheme on the Upper Hudson River.—The Hudson River Water Power Co. has been formed with a capital stock of $2,000,000, and an allowable bond issue of $1,500,000, for developing the power made available by the Hudson River between Palmers Falls and Glens Falls, N. Y. This is about 30 miles above the well-known Mechanicsville plant of the Hudson River Power Transmission Company, which supplies power to the General Electric Company at Schenectady. The prospectus of the new concern states that the plant will consist of a dam 72 feet high, to be constructed upon solid rock, and to be capable of developing 10,000 h.p. in the dryest time of the year and from 15,000 to 20,000 h.p. at other times. The present minimum flow of the river will be increased by the carrying out of the plans of the Forest Preserve Board of New York State, which provides for a system of storage reservoirs in the Adirondack region for equalizing the flow of the river. One large reservoir at Indian Lake has already been completed. The power will be transmitted to many points, such as Saratoga Springs, Fort Edward, Ballston Spa, etc. It is estimated that 10,000 h.p. can be sold at a minimum rate of $25 per horsepower year. The prospectus further states that no other available site for power development exists upon the Hudson River which is not already utilized. The company owns the Saratoga Gas, Electric Light & Power Company, which at present has net earnings of over $40,000 per year. Mr. William Barclay Parsons, well known as the engineer of the Rapid Transit Commission of New York City, has taken entire charge of planning and supervising the construction of the power plant.

A Further Consolidation of Electric Lighting Interests in New York City.—The Consolidated Gas Company of New York City, which is a Standard Oil or Rockefeller interest, and which controls the United Electric Light & Power Company of New York, has, it is announced, purchased a large interest in the New York Gas, Electric Light, Heat & Power Company, which is the Whitney Syndicate consolidation of the New York, Edison and various other lighting companies on Manhattan Island. The United Electric Light & Power Company is known as the Westinghouse central-station interest in New York City, a large amount of its stock having been held until recently by Mr. George Westinghouse. Outside of those absorbed by the Whitney Syndicate, it controlled all the older companies in the Borough of Manhattan, i. e., lesser New York, excluding Brooklyn and the suburbs. This most recent consolidation, therefore, brings together all central-station properties in the city proper and associates them with one of the powerful gas companies. That the Rockefeller and the Whitney interests are working in harmony is indicated by the election of Mr. Anthony N. Brady to the presidency of the Consolidated Gas Company, as well as to that of the New York Gas, Electric Light, Heat & Power Company. Mr. Brady has also been elected President of the King's County Electric Light & Power Company of Brooklyn, which controls the Brooklyn Edison and other lighting interests in that borough. This unity of ownership suggests again the possibility of electrically tying the Brooklyn and the New York systems together by means of trunk feeders between the central stations or centers of distribution in order that one may help the other at times of overload or emergency. The New York company is building a mammoth generating station, described in the last issue of the American Electrician, which will generate three-phase currents at 6600 volts. The Brooklyn company already operates a station of the same type at the same frequency, with the same number of phases and the same pressure. In this connection it is interesting to note a recent letter from Mr. George Westinghouse to the "New York Times," which reads as follows:

"The bringing together of the gas and electric light and power interests in New York should result in great advantages to the public and to the interests so combined, provided the latest developments in gas and electric engineering are investigated and availed of. Among the numerous questions affecting the health, comfort and convenience of the citizens of New York (and of all communities, in fact) are three of especial importance, viz.:

"The disposal of garbage, the abatement of the smoke nuisance due to the increasing use of bituminous coal for steam-power purposes, and the securing of an adequate supply of water.

"From statistics there appear to be created daily in New York about 500 tons of garbage, or at the rate of one-half pound per capita. Such garbage is about 20 per cent. carbon and 80 per cent. water. By a process which has been well demonstrated on a small scale, and which is being rapidly brought to a commercial basis, all of this garbage can be economically, and without offensive odor, converted into a fuel gas of great value. In the same apparatus, and by the same process, soft coal can be made into a gas suitable for power and heating purposes.

"The fuel gas made from garbage and soft coal can be used to drive gas engines with electric generators, and the electricity thus produced can be used for light and to drive motors to the exclusion of the thousands of steam engines and boilers which make such demands upon the water supply, since the gas engine central stations can be so located that the water needed for engine cooling purposes can be taken from the river.

"Bearing upon these questions and of especial importance, are the partially executed plans of the electric power and light corporations, viz.: The Metropolitan, Third Avenue and Manhattan Elevated Railways, and the New York Gas & Electric Light, Heat & Power Company, and the United Electric Light & Power Company. If their present plans, which are fairly well known to the engineering profession, are carried to completion, each will have one large steam station on the East River, between Twenty-ninth Street and the Harlem River, with about 75,000 h.p. of engines, boilers and electric machinery, making an aggregate of 375,000 h.p., and which may be largely increased when the underground rapid transit railway is completed; and still further when the electric locomotive is used on all steam railways within the city limits.

"If these corporations, which might as well buy electricity as the machinery, coal and water with which to produce it, were to unite in a common plan to provide the electricity needed in their operations by the adoption of the best available methods, the saving to each in capital expenditure would be very great, and the decreased cost of their supply of electricity would make an important addition to their earnings applicable to the payment of dividends; while, most important of all, the citizens of New York would have solved for them the garbage, smoke and very largely the water questions.

"I believe the contemplated plans of the corporations above named, which can be shown to be based upon an imperfect knowledge of the subject, will stand in the way of vast public interests, and, so believing, I have said to representatives of some of those companies that the near future would demonstrate the projected power stations and systems of electrical distribution incidental to the character of such stations, to be as far from the best as are the old cable systems for the propulsion of cars.

"I write this letter because I believe these subjects are just now worthy of investigation, discussion and elaboration."

Mr. Westinghouse again shows in his letter his advanced ideas as to the tendency of future development, which ideas, taken into connection with his accurate predictions in the past, must carry considerable weight. His statement as to the use of garbage is of interest, as this work has never been taken up in this country as it has in England. His opinion that the mammoth multiphase installations now under construction, and considered examples of the most advanced practice, are far from the best arrangement, refers undoubtedly to the transmission of power by means of gas, recently referred to in these columns.

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60-Cycle Double-Current Generators.

There will be found on another page a description of an electric railway power station containing generators, each of which delivers both direct and alternating current, the former for adjacent sections of the trolley line and the latter for high-tension transmission to sub-stations, where it is converted into direct current for the distant sections of the line. An interesting feature of this and one other similar installation previously completed, viz., that of the Lewiston, Brunswick & Bath Railway in the State of Maine, is the fact that the alternating currents have a frequency of 60 cycles per second, which is unusually high for rotary converter purposes.

This frequency suggests the possible use of generators of this kind for central stations supplying both direct and alternating-current loads. One type of machine could be used to deliver three-wire direct current to lights and motors in the central downtown district of crowded loads and also to deliver 60-cycle alternating currents to scattered residential suburban loads. Incidentally the low-tension primary windings of the station step-up transformers for the alternating loads could be used for tapping in the neutral of the three-wire direct-current system into one armature winding generating 240 volts between the brushes. Unfortunately at present engine speeds are so small that direct-coupled machines of this frequency have their poles too crowded for direct-current work, so that under existing conditions belted generators are necessary to obtain 60 cycles and direct current from one armature.

Lighting from Primary Batteries.

On another page there will be found an article on this topic which is unique among literature on this subject in being based upon experience in the construction of an actual installation. Successful operation from the dollars and cents standpoint depends on the use of lamps having the astonishing economy of one watt per candle power, which is about three times as efficient as the best lamps now commercially in use. Although these lamps work at the very low pressure of 14 volts, under which condition, of course, a considerably greater economy can be expected than is to be found at 100, or even 50 volts, it is difficult to believe that any such sustained economy combined with reasonable life can be attained. The writer of the article states that he has tested the lamps and found that they showed initially nearly the figures claimed, although he has not had sufficient time as yet to make any determination of the life or maintenance of candle power.

Separately Fired Superheaters

The article on another page on the advantages of superheated steam is of particular interest, as it is written by a collaborator of Prof. V. Dwelshauvers Dery, who has done considerable original work in this field of steam engineering. The article describes a superheater in which the hot gases directly from the fire are brought in contact with the superheating tubes without being previously cooled by tubes containing water. The tubes of this superheater are unique in being made of cast iron one inch in thickness, the internal diameter being four inches and the external diameter six inches. They are fitted so that each one can be rotated from time to time to take out the bending which the writer states is caused by unequally distributed heating.

The Cure of Electrolysis.

Wherever in this country the leakage from street railway returns has become sufficient to cause serious electrolysis of the underground pipes, cable sheaths, etc., any attempt made to cure it has been by means of auxiliary or independent returns, which, so to speak, drain out all current from the piping affected without compelling it to pass from the surface of this piping into the ground. A few of these independent returns judiciously located and connected up so lower the potential of the pipes or cable systems affected that all current flows into them from the ground instead of out from them into the ground, thus rendering them safe, as current flowing from ground to pipe causes no destructive corrosion but tends, on the contrary, to deposit any metallic substance that may be contained in the moisture in contact with the metal.

An article on another page gives a general resume of the subject and many practical directions and points out some interesting conclusions, such as the fact that the protection of one system of piping in a given territory, such for example as water or gas mains, tends to endanger others in the same streets, such for example as electric cables.

The complete protection of extensive networks in large cities requires no small amount of copper. It might prove more economical in some instances to drain the current out of the piping by means of low-voltage generators, which could be connected to the pipes by comparatively small conductors and which could be made far more effective than any auxiliary returns ever could be, by lowering the potential of the piping even below that of the negative bus bar if necessary. A pressure of 10 or 15 volts would probably prove sufficient for severe cases, and it would require a large network of piping or cable sheathing to collect 100 amperes. The one or one and one-half kilowatts thus spent would cost but a trifle to central stations or even to large telephone companies operating their own power plants. If judicial opinions holding the railway companies liable for electrolytic damages continue, these companies themselves would find it a paying investment to install such negative boosters for the current which they could collect from the piping systems of other corporations operating in their territory. The best location for such machines is, of course, where the cables or pipes to be protected concentrate, and as near as possible to the negative bus bar of the traction system. In most places where the central station, the telephone exchange, and the railway power house are near together in the center of the city the location and wiring of such a negative booster would prove an easy problem.

Manhole Explosions.

For the occasional cases of ignition of the explosive mixtures of gases in underground conduits of so-called high-tension systems, several causes are now well recognized. In addition to burn-outs and static there is the alternating electromotive force which is set up in the sheaths of single-conductor cables carrying alternating currents. The conductors of two such cables constituting one feeder act as the primary of a long drawn out transformer, the two lead sheaths acting as the secondary and the space between the two cables acting as an air core. If the lead sheaths are connected together at their two ends secondary currents will flow around the loop formed, and if not the e.m.f. set up may be sufficient to burn out any small conductor connecting the two cable sheaths, and cause an arc and explosion. This e.m.f. is equal to the counter e.m.f. of self induction set up in the cores of the cables, as it is due to exactly the same cause. It is proportional to the amount of current flowing and to the distance between the cables. For cables one foot apart it amounts to about 5 volts per thousand feet of feeder length with 100 amperes at 60 cycles. The e.m.f. set up in cable sheaths one mile long will easily melt a piece of No. 12 wire a foot in length.

It is comparatively hard to account for similar accidents on telephone and telegraph conduits. One probable cause that is rarely suspected is the continuity of overhead and underground cable sheaths. Telephone cables running out from an exchange frequently run part way underground and then rise to the poles, continuing overhead to the distributing boxes. The overhead sections may at any time become connected with overhead trolley lines or other sources of high potential tending to give a heavy current to ground. In this case sparks, arcs or burn-outs may occur at any point underground where the cable sheath affected comes near or in contact with other conducting bodies.

The evident means of curing this danger, once it is appreciated, is the use of insulating splices between the overhead and the underground sections of a cable sheath. Such insulating splices can readily be made sufficiently waterproof to avoid the introduction of moisture, in several ways that will suggest themselves to engineers engaged in such work. By the use of compounds, tape and wrappings, and preferably a wooden housing around the splice, which should of course be located above ground, the moisture can be excluded. If it is desirable to introduce such an insulating joint in a cable sheath where a splice does not come handy, a split sleeve can be employed, wiped to the leath sheath at one end and insulated at the other end, suitably compounded, taped, wrapped and protected from the weather.

Aluminum Cable Sheaths.

Attention is called to the suggestion made in the last issue of the American Electrician that aluminum be used in place of lead for cable sheaths, by the letter published in another column of this issue from the Pittsburgh Reduction Company. The letter points out some possible difficulties of manufacture which are, however, not very serious. It is apparent that the greater heat required for squirting aluminum compared with that for lead might endanger the insulating material around which the aluminum would be placed unless the insulation were protected in some way, as it could readily be by a thin covering of some non-carbonizing insulator, such as asbestos. The increased pressure required for squirting aluminum could of course be applied without transmitting it to the contents of the cable.

The suggestion in the last issue of the American Electrician was that the aluminum be used for the cable sheaths of low-tension lighting systems and that its conductivity be utilized for a neutral return. This presupposes not only that grounding of the neutral be openly allowed, as the increasing use of high-potential three-wire systems must soon compel it to be, but that a ground of the neutral throughout its length becomes recognized good practice in this country as it already is in Germany.

It is obvious, however, that there is one other instance where aluminum could be at once used in this way to great advantage to replace not only copper of equivalent conductivity and hence greater cost, but also of considerable lead at the same time. This is for the sheathing of the underground feeders of traction systems. In large cities many insulated and lead-covered cables are drawn into conduits for feeding the overhead lines, and bare copper cables of perhaps one-third to one-half as great a cross section are drawn in or laid in the ground to re-enforce the rail return. If the cable sheathing of the insulated feeders were made of aluminum it could be made to serve as the re-enforcement of the rail return, doing away with the uninsulated copper cables.

The use of aluminum for the cores of insulated underground cables has been looked upon as out of the question, owing to the increased cost of insulation and lead, due to increased diameter necessary for the same conductivity as copper. If the cable sheath were utilized for conducting purposes—as proposed above—as well as for mechanical protection, the slightly increased cost of paper insulation probably would not offset the saving of aluminum over copper. It is possible that we may soon see cables for traction purposes with aluminum cores and aluminum sheaths.

DESIGNS FOR SMALL MOTORS.

THE WINDING OF THE ONE H. P. FOUR POLAR MOTOR.

BY CECIL P. POOLE.

The four field coils for the cast-iron magnet frame described in the preceding article are of No. 21 single-cotton-covered magnet wire. The depth of the winding must be 1¼ ins., as nearly as possible, and the length along the core should be 2 ins. Careful and close winding should give 40 layers of wire, with 58 turns to a layer. Whatever number of turns the reader may obtain, that number must be precisely the same in all four coils. In order to attain uniformity the coils should be wound upon a frame and the turns religiously counted. A winding frame for such a purpose was described in connection with the motor design published in the American Electrician for January, 1899. In this same article full instructions for securing the ends of the coil and insulating it with tape were also given. It will be found advantageous to tie a knot in the starting end of each coil before taping it so that it may be identified afterward. The coils must be connected up as shown by the diagram, Fig. 15, so that the starting end of one connects to the finishing end of its neighbor. This presupposes that all four are wound in the same direction, as they should be.

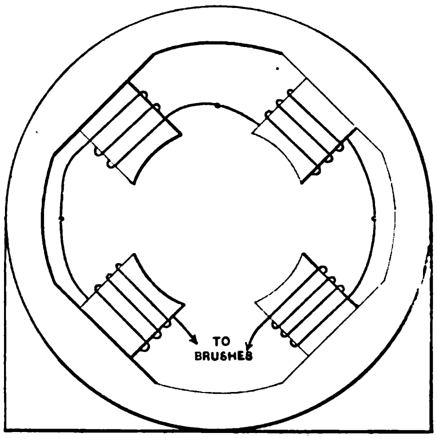


FIG. 15.—THE CONNECTIONS OF THE FIELD COILS, SHOWING HOW THE CIRCUIT SHOULD RUN IN OPPOSITE DIRECTIONS AROUND ADJACENT POLES.

The coils for the cast-steel magnet are of No. 24 single-cotton-covered wire, 1⅛ ins. deep and 1⅞ ins. long. Good winding will enable the reader to put on 50 layers of wire and 75 turns to a layer. As in the previous case, however, the depth in inches is the essential point, though it is advantageous to get as many layers in that depth as possible. The coils are, of course, wound, insulated and connected up exactly like the oblong coils of the cast-iron frame.

The armature core for either of the magnet frames will contain 32 coils; each coil consists of No. 21 double-cotton-covered wire, wound five turns wide by four layers deep. Each slot contains one side of each of two coils, so that the cross-section of the winding in a slot will be as in Fig. 16, except that the wires will lie closer together than the sketch indicates.

All armature coils should be wound on a forming bobbin so that they will all be exactly alike. Fig. 17 shows what the essential dimensions should be. The width of the hollow of the coil is the same for both armature cores. As the armature core to be used with the steel magnet is an inch shorter than the other one, the coils for this core must be an inch shorter; hence the two dimensions for coil lengths.

Fig. 18 is a winding diagram and shows the first four coils in position. The coils are indicated by single lines across the head and dots in the slots for simplicity. The builder should note that the left-hand side of each coil is in the bottom of the slot and the right-hand side is on top; this should be true of every coil. The starting ends should be knotted for identification, and all the knotted ends should occupy the same relative position on the core. For smoothness of finished heads the coils should be put on the core in the following order:

Coils 1, 2, 3, 4 in Slots 1, 9, 17, 25.
Coils 5, 6, 7, 8 in Slots 2, 10, 18, 26.
Coils 9, 10, 11, 12 in Slots 3, 11, 19, 27.
Coils 13, 14, 15, 16 in Slots 4, 12, 20, 28.
Coils 17, 18, 19, 20 in Slots 5, 13, 21, 29.
Coils 21, 22, 23, 24 in Slots 6, 14, 22, 30.
Coils 25, 26, 27, 28 in Slots 7, 15, 23, 31.
Coils 29, 30, 31, 32 in Slots 8, 16, 24, 32.

If put in properly, the coils will give a regular sequence of knotted ends and straight ends, one each projecting from each slot. The connections to the commutator are then simple. Carry all the knotted ends straight out to the commutator, and the straight ends a quarter circle further away from their corresponding knotted ends. Thus, the knotted end from slot No. 1 goes to commutator segment No. 1 (see Fig. 19), and so on, all the way around. Then the straight ends go to the commutator as follows:

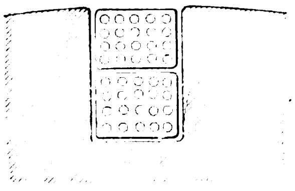


FIG. 16.—SECTION THROUGH SLOT, SHOWING ARRANGEMENT OF COILS.

From Slot No. 1 to Segment No. 8.
From Slot No. 2 to Segment No. 9.
From Slot No. 3 to Segment No. 10.
From Slot No. 4 to Segment No. 11.
From Slot No. 5 to Segment No. 12.
From Slot No. 6 to Segment No. 13.
From Slot No. 7 to Segment No. 14.
From Slot No. 8 to Segment No. 15.
From Slot No. 9 to Segment No. 16.
From Slot No. 10 to Segment No. 17.
From Slot No. 11 to Segment No. 18.
From Slot No. 12 to Segment No. 19.
From Slot No. 13 to Segment No. 20.
From Slot No. 14 to Segment No. 21.
From Slot No. 15 to Segment No. 22.
From Slot No. 16 to Segment No. 23.
From Slot No. 17 to Segment No. 24.
From Slot No. 18 to Segment No. 25.
From Slot No. 19 to Segment No. 26.
From Slot No. 20 to Segment No. 27.
From Slot No. 21 to Segment No. 28.
From Slot No. 22 to Segment No. 29.
From Slot No. 23 to Segment No. 30.
From Slot No. 24 to Segment No. 31.
From Slot No. 25 to Segment No. 32.
From Slot No. 26 to Segment No. 1.
From Slot No. 27 to Segment No. 2.
From Slot No. 28 to Segment No. 3.
From Slot No. 29 to Segment No. 4.
From Slot No. 30 to Segment No. 5.
From Slot No. 31 to Segment No. 6.
From Slot No. 32 to Segment No. 7.

The commutator must have 32 segments, as indicated by Fig. 19, and should be purchased already built for assured satisfaction. The brush surface of the commutator must be 1¼ ins. long, at least, so that carbon brushes 1 in. wide and ¼ in. thick can be used. The diameter of the barrel of the commutator should be not less than 3, and preferably 4 ins. The brush holders and yoke may be copied advantageously from any of the standard machines now on the market. Four brushes must be used, and the two diametrically opposite are connected together, as shown by Fig. 20.

The windings just described are for machines to work on a 110-115-volt circuit. If windings for 220-230 volts are desired the armature coils should be of No. 25 wire, each coil five layers deep and eight turns wide, making ten layers of wire per slot. The field coils of the cast-iron magnet must be of No. 24 s.c.c. wire, wound to the dimensions specified above, namely, 1¼ ins. deep and 2 ins. long. The coils for the cast-steel magnet will be of No. 27 wire wound to a depth of 1⅛ ins. and a length of 1⅞ ins.

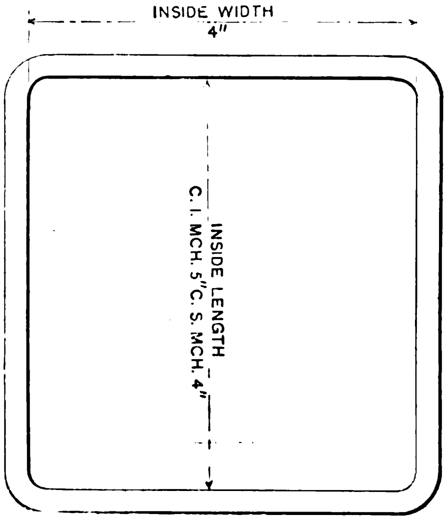


FIG. 17.—DIMENSIONS OF FORM-WOUND ARMATURE COILS

The principal magnetic and electrical data of the two machines are as below:

115-VOLT MOTOR.

	Cast-iron.	Cast-steel.
Res arm. winding	1 ohm.	0.9
Normal arm currents.....	9 amp.	9 amp.
C^6R loss armature	81 watts.	73 watts.
Hysteresis and eddy currents..........................	4⅛ watts.	3 watts.
Approximate speed........	1600	1600
Res. field winding.....	183 ohms.	424 ohms.
Normal field current.......	.628 amp.	.27 amp.
C^2R field loss................	72.22 watts	31 watts.
Flux per pole..............	400,000 lines.	
Density in field cores.......	48 000	53 000
Density in air gap..........	37,500	37,500
Efficiency, assuming...... 10% friction and windage.	75%	80%

No design for a starting rheostat has been given because the reader can buy a modern rheostat with no-current release for about the same money that materials for a home-made starting box would cost, and there is no comparison between the merits of the market apparatus and the home-made one.

INTERIOR WIRING.

BY CHARLES E. KNOX.

SWITCHBOARD DESIGN.

The design of a switchboard for an interior-wiring installation depends largely on whether a plant is to be installed as a part of the installation or whether the current supply is to be obtained from an outside source. For this reason we will consider the subject separately for each case.

1st.—CURRENT SUPPLY TAKEN FROM STREET MAINS.

When no plant is installed, the design of the switchboard is relatively simple. As a rule a switchboard for such an installation is usually nothing more than an enlarged feeder-panel board such as was described in the last article. It is only necessary in most cases to provide a switch with fuse blocks for each of the outgoing feeders, a suitable place for mounting the meter, and the necessary lugs, etc., for making the connections between the service feeder and the bus bars. When it is desired to place this switchboard against the wall, the board is treated exactly as though it was a panel board, and is enclosed in a cabinet, with a connection compartment around it. In this case the cabinet is, of course, much deeper and the connection compartment is much wider, being sometimes from 8 to 12 inches in width.

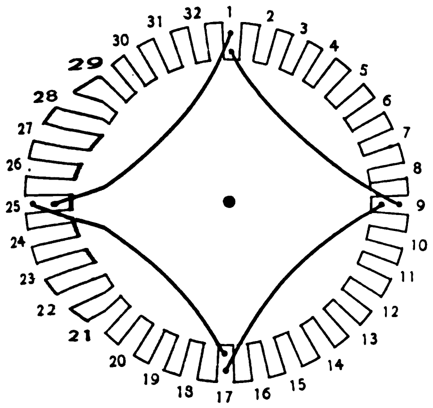


FIG. 18.—ARRANGEMENT OF COILS.

In cases where the current is used for both lights and power it is nearly always necessary to have two sets of bus bars, one of which serves to supply the lighting feeders, the other to supply the power feeders. The reason for this is that the rate charged for power being usually different from the rate charged for light, the current for each purpose is supplied by a separate feeder and is measured by a separate meter.

It is seldom deemed necessary to have any other measuring instruments on a switchboard of this character beside the wattmeter. As this instrument only measures the total power consumption in watts and gives no indication of the load at any one time, it may be desirable in some cases to supplement it with other instruments. In many cases a voltmeter would be useful, as it might be so connected as to make it possible to determine the voltage of the service current and also to determine the presence and location of "grounds" or short circuits on the installation.

2d—CURRENT SUPPLY TAKEN FROM LOCAL PLANT.

In this case the design is, of course, more complicated, and sometimes involves considerable thought and ingenuity.

Before starting in to design a switchboard of this kind it is necessary to determine, first, the number and capacity of the generators constituting the plant, the number of and the load carried by the various feeders originating at the switchboard, the number and kind of measuring instruments, etc. A general plan should also be formed, first, of the manner in which the plant is to be operated. In some cases, where a considerable amount of current is used for power, it may be found advantageous to have separate panels for light and for power, and to so arrange the dynamos that power and lighting circuits may be supplied from separate generators. In other cases it may be necessary to make provision for a storage battery.

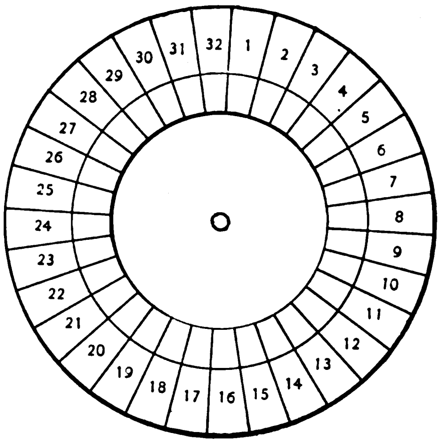


FIG. 19.—SEQUENCE OF COMMUTATOR SEGMENTS.

Let us take a simple case first. Given an installation having one generator, and lighting feeders only, to design a switchboard which will serve for operating, controlling and protecting the dynamos and feeders. At the outset it is necessary to know whether there are restrictions as to the cost of the switchboard, other than the natural law, that the best possible outfit be obtained for the least possible outlay. If it is absolutely necessary to keep the first cost down to a minimum, the design of the switchboard must be made accordingly. In such a case slate may be used for the panels instead of marble. A double-pole switch with fuses should be provided for the dynamo. If there is a possibility of another dynamo being added later, the dynamo switch should be made triple pole, as this is necessary on account of the equalizer connection. If, however, one unit is all that will be required, the equalizer connection is, of course, unnecessary. A regulating rheostat, voltmeter and ammeter would complete the switchboard appliances which would be necessary and almost indispensable for the control and operation of the dynamo. It would be well, if possible, to add to this list an electro-magnetic circuit breaker, as this appliance would not only afford additional protection, but would also add to the convenience in operating the dynamo, as it is, of course, easier to close a circuit breaker which has been thrown out by overload or by short circuit than it would be to replace a blown fuse. As to the feeder portion of the switchboard, it is only necessary to provide a single-throw switch with fuse blocks for each feeder. These feeder switches should be either double pole or triple pole, depending upon whether the two-wire or three-wire system is used; or, in case the two-wire system is used, whether provision should be made for using the three-wire system at any future time. A drawing should, of course, be made, giving general dimensions of the switchboard, showing the general arrangement of the dynamo appliances and also showing the number and arrangement of the feeder switches.

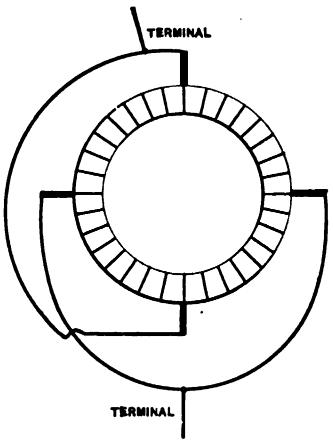


FIG. 20.—CONNECTIONS OF BRUSH HOLDERS.

In laying out the appliances on the board the following points should be borne in mind. All switches should be within easy reaching distance of the operator; the indicating instruments should not be placed so high as to make it difficult to read them; if electro-magnetic circuit breakers are used they should be placed near their corresponding switches, so as to shorten the bus bar work between them. As a general rule, the rheostat should be placed in such a position as to allow the operator to watch the voltmeter when using the rheostat.

Where it is necessary to place the switchboard against a wall, it is permissible to put all the bus bar work on the front, provided all connections between the feeders, bus bars, etc., are made on the face of the board. Where this can be avoided, it is certainly better to do so, as it greatly complicates the design of the switchboard, the connections between the feeders and the switches, and also increases the liability of accidental "short circuits" on the bus bars. Let us presume, then, that the switchboard is to be set out from the wall a sufficient distance to allow access to it from all sides, and that all connections are to be made on the back of the board. So much for the arrangement of the appliances on the front of the board. The design of the rear of the board next requires attention.

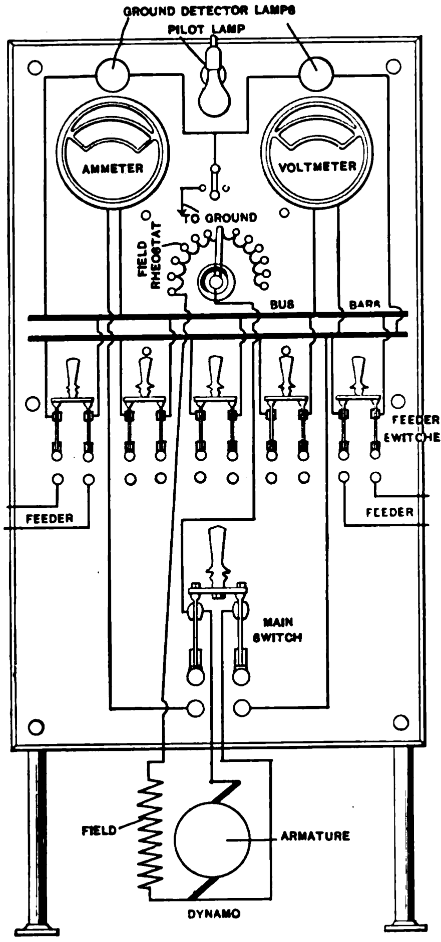
It is the design of the rear portion of the switchboard that really brings the experience and ingenuity of the designer into play. In the case we have been considering (where there is only one generator and only lighting feeders) the matter is relatively simple. But where there are several generators and both lighting and power feeders, the "plot begins to thicken." If, in addition, there is a storage battery to be used in supplementing the generators, the design becomes quite a serious problem.

It will be well at this point to discuss the material used in the bus bars, lugs, switches, etc., and to give the current densities allowable under various conditions. And also the general rules followed in making and mounting the switches, bus bars, etc.

Bus Bars.—So far, nothing has replaced pure cold-drawn or rolled-copper for bus bars. This copper should have a conductivity of not less than 95 per cent. Several attempts have been made within the last few years to replace drawn copper by so-called "cast" or "process" copper, but the attempt has been unsuccessful for the reason that the conductivity of these substitutes has been not only lower but has been very variable and unreliable. This kind of copper is also liable to contain blow holes. The safest plan, therefore, is to use the drawn or rolled copper. The allowance in current density for drawn copper of not less than 95 per cent conductivity should be not greater than 750 to 800 amperes per square inch of cross-sectional area. The current density allowable for surface contacts on bus-bar work should be not greater than 100 amperes per square inch of surface.

Bus bars having a sectional area greater than 2 square inches (say 4 inches wide and ½ inch thick) are generally composed of two or more separate bars connected in multiple. The usual construction followed where a set of multiple bus bars is used is to separate the bus bars about one-quarter or three-eighths of an inch, so as to afford a greater radiating surface and thereby maintain the bus bars at a lower temperature. The connection between two sets of multiple bars is made by alternating the bars of each set, i. e., placing the bars of one set between the corresponding bars of the other set. Every precaution should be taken in the design of the bus-bar work to insure good contact between the various sets of bus bars. When the bus bars are less than two inches wide, one bolt may be sufficient for clamping the bus bars together. When the bus bars are 2 inches or over in width two smaller bolts should be used. In general, every precaution should be taken to provide good contacts at all junctions or connections, as it is at these points that troubles from undue heating arise.

Switches.—The same remarks as to the material used and as to the allowance for current densities applies to switches as those stated above for the bus bars, with one exception. This exception relates to current density allowable for surface contact. As the contact of moving surfaces is much more variable, and is more liable to a reduction owing to lack of imperfect contact between such surfaces, it is necessary to reduce the current density in moving contacts. For switches, therefore, the allowance for stationary-surface contact may be 100 amperes per square inch, but the allowance for moving contacts should not exceed 60 to 75 amperes per square inch of surface. The same rules hold good in regard to the clips and blades of the switches.



ELEVATION OF A SIMPLE SWITCHBOARD FOR AN ISOLATED PLANT, WITH ONE DYNAMO, SHOWING CONNECTIONS OF APPARATUS.

Switches having a capacity of more than 200 to 300 amperes are usually made with multiple blades, so as to increase the amount of surface contact and also the radiating surface.

Lugs.—As it would be very difficult, if not impossible, in many cases, to make lugs of drawn copper, they are usually made of cast copper. The current density should, of course, be reduced to correspond with decreased carrying capacity of the material. This, of course, depends upon the conductivity of the cast copper.

In the design of switchboards the matter of the kind of lug to be employed is certainly not given the attention which it deserves and requires. As a rule, standard (straight) lugs are furnished where a special lug should be designed for the particular purpose for which it is to be used. In many cases lugs having an angle of 45 degrees can be used to much greater advantage in making the connections than a straight lug. In other cases a right-angle lug would better be employed. The style and size of lug should be shown as a part of the switchboard design, a rule which is very rarely followed.

ELECTRIC LIGHTING FROM PRIMARY BATTERIES.

BY F. E. WOODFORD.

The questions are often asked by people living in the rural districts: "Is it possible to light a country residence by electricity with any degree of economy? Can we have our homes brilliantly lighted like those in the city if we are not within reach of a city lighting station?" These questions and many similar ones on the same subject are not unnatural when we drive through the country and see the farm houses heated by furnaces or steam and having a water system all their own. Many villages and even small cities throughout the country do not have lighting stations or pumping stations, and in such places a well, a windmill and a water tank elevated to supply the house is not an uncommon sight. Why should not these people be accommodated to that other comfort of life, the electric light?

The problem, of course, is not a hard one, as several ways present themselves. A small dynamo driven by a gasolene engine is a very simple arrangement; while, if fortunate enough to be located near a stream, a small turbine may be made to take the place of the gasolene engine. But these plants need some attention, have to be started when the lights are used and stopped at bed time. And later in the night, of course, a lamp cannot be turned on at will as one could if attached to a city plant. Added to these difficulties of using a dynamo, either of these plants is quite expensive. The cheapest one that could be installed, even in a small house, would cost from $500 to $600. What people thus situated need is a system of lighting that does not cost too much at the start, is easily and cheaply maintained and operated and one that is always ready for use without the preliminary operation of "getting it started" each evening.

With this end in view it is plain that mechanical power is quite out of the question, and we must resort to something in the line of a battery. As gravity cells generate the greatest amount of current, for the money expended, of any battery, these we will use. But as they must be kept on closed circuit to get their best efficiency, during the day we will keep them closed on some storage cells, which, together with the gravity cells, will operate the lights at night.

The secret of the successful operation of such a plant lies in determining as near as possible the average number of lamp hours per day the battery will be called upon to supply, and from this selecting, the size and number of both primary and secondary cells that will meet this demand, as well as give best adaptation of the two batteries to each other. To describe such a plant in detail and make an estimate on its first cost and the cost of operating, I will have to take a house of average size as a basis, and the reader must judge from that in estimating larger or smaller ones. A house consisting of six rooms below and four above, we will say, could be lighted with seventeen 16-c.p. lamps rightly distributed, provided the rooms were not too large. But as we are to light it with batteries, instead of using 16-c.p. 110-volt lamps we will use 14-c.p. battery lamps, which require one ampere each at 14 volts. Where we would have three 16-c.p. lamps in the parlor, we will use four of the battery lamps, and in some of the other rooms increase the number of lights by one likewise. In a small bed room or hall, however, one could scarcely distinguish between the two, and one battery lamp would be quite sufficient. A wise distribution of 24 14-c.p. lamps will, therefore, light this house even better than would the 110-volt lamps. Out of this number it is safe to say that eight will be the average used in a house of these dimensions. If the lamps were burned four hours per day, which would probably cover the time, we would have to supply per day with the batteries an average of 32 lamp-hours or ampere-hours, as each lamp requires one ampere.

The storage cells must be large enough to carry the total number of lamps for an evening without injury, although they would seldom be taxed to that extent. They can, therefore, be cells that are capable of discharging themselves in six hours at the rate of 24 amperes. If this is their highest rate of discharge, their normal rate will supply our average demand very nicely. Cells whose normal rate of discharge is 10 amperes will meet this requirement. To determine the size of the primary cells we must resolve the 32 ampere-hours into its equivalent, or 1 1/3 amperes for 24 hours, as the generator is working continually. To this amount we will add 12½ per cent. for the loss between primary and secondary cells, and for such other losses as may occur, making 1½ amperes to be delivered by the gravity cells continuously.

A 9 by 12-inch cell can be depended upon to deliver ½ ampere for a period of two months without attention, so therefore three of these cells in multiple will answer our purpose to deliver the proper ampereage. It will require eight storage cells in series to keep the voltage up when the cells are nearly discharged, and 34 gravity cells in multiple series to fully charge this storage battery. The connection of the two batteries with each other and with the lamps is shown in the accompanying diagram. A consists of six storage cells, charged by 30 gravity cells in multiple series, 10 in each series. B and C are each one storage cell, each charged by two gravity cells in series, no multiple cells being required in this case as the average load on these cells is less than on the others.

The cells are connected to the lights, as shown in the diagram, through a controller, which should be placed at some convenient place in the house as near to the batteries as is possible. This controller consists of a lever and 15 or more points in its circle, these points connected, as shown, to three resistance coils at the back. When any lights are thrown on with the controller lever at the top, it brings battery A into service with resistance in its circuit. As the lever is moved to the right this resistance is gradually cut out until the cells are closed directly on the lamps. The next step throws battery B in series with battery A, together with new resistance, which also is gradually cut out as the controller lever is moved still farther. This same operation is again repeated with battery C. It is advisable to have as many points as possible in the controller, thus making the step from one to the other less marked, and the points to which the ends of each of the three resistance coils are secured should be placed farther apart than the others, to insure the levers not being left across the two, which would short circuit part of the battery. The others may be very close, as in a resistance box. A controller thus arranged will throw into service any combination from six cells with suitable resistance in its circuit, to eight cells without resistance. We therefore do not lose the energy that we would were the eight cells connected in series and the controller a mere resistance box, throwing in sufficient resistance at the start to bring the voltage of the freshly charged cells down to that required at the lamps.

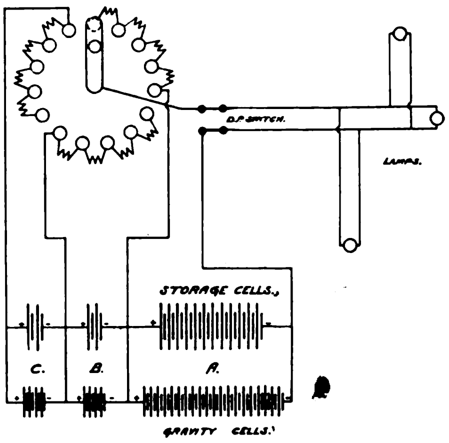


DIAGRAM SHOWING CONNECTIONS OF GRAVITY CELLS, STORAGE CELLS AND LIGHTING CIRCUITS.

The four gravity cells charging batteries B and C may be old ones, or, when started, the liquid need not be of the same strength as the others, as they will not be taxed to the same extent. And it may be found in some instances that battery C can be charged with two cells of a much smaller size.

The wiring of this house from the controller to the lamps must be done with a good deal of precision to secure the best results. While we will need no fuses on account of the low voltage we are using, for this same reason we are compelled to be more particular in the size and length of the conductors. No smaller than No. 8 wire should be used from the battery to the controller, and if this is not about centrally located in the house, this size should be continued to some point as nearly central as possible. From these feeders several mains of No. 12 wire should be run to each room, and all branches may be of No. 14 wire, but the arrangement of the mains ought to be such that each branch will be about the same length and as short as possible. This can easily be done if these three sizes of conductors are used, although the rooms may vary largely in size and shape. Careful attention to the wiring is very necessary in order to have all the lamps burn at the same brilliancy, as a slight drop in voltage is noticeable in low-volt lamps.

To make an estimate on the cost of this wiring would be a difficult matter, as the shape and size of the house would make each case different, and the cost of chandeliers and brackets varies so widely that no definite figure could be put upon it. But we can place this at a medium price, and knowing the cost of the cells of battery described, we can make a very fair estimate of the whole, which would be as follows:

Cost of wiring, including lamps, sockets and brackets	$75 00
Cost of 8 storage cells at $8.00	64.00
" " 34 gravity cells at 50 cents	17.00
" " controller	5.00
	$161.00

If the average amount of light is used, as described above, the gravity cells will have to be replenished about every two months, which will cost about $6 for the 34 cells, making a total cost of $36 per year. A good way is to renew part of the gravity cells at different times, as it takes a day or so for the cells to get into action. While the batteries would have to be attended to more often, it will not harm the plant in any way to burn more lamps each night, as the gravity cells begin to furnish current to the system as soon as the voltage of the storage cells is lowered enough to allow it. Neither would it overtax the plant to have all the lamps of the house turned on for the evening. Still it will be found to work with nearly the same degree of economy if only one or two lamps are to be used, the storage and gravity cells adjusting themselves to each other automatically.

The various uses to which electricity is now put in almost every house make one of these little plants desirable in a country residence in a number of ways. Door bells and other similar apparatus may be operated on wires taken from any one of the storage cells, and a system of burglar alarms may be operated from part of the gravity cells. Lamps of a less candle power may be used in any of the rooms as night lights, and, as the batteries are always ready, may be turned on at any time. A physician who has his office in his house, as is often the case in country towns, may make use of this battery for therapeutical work. If connected properly to his cabinet switchboard it will be found to have ample capacity for all his needs. And while other uses may present themselves in various instances, as a lighting plant alone this system is well worth consideration, as it is simple and compact in itself, and ever ready for immediate use.

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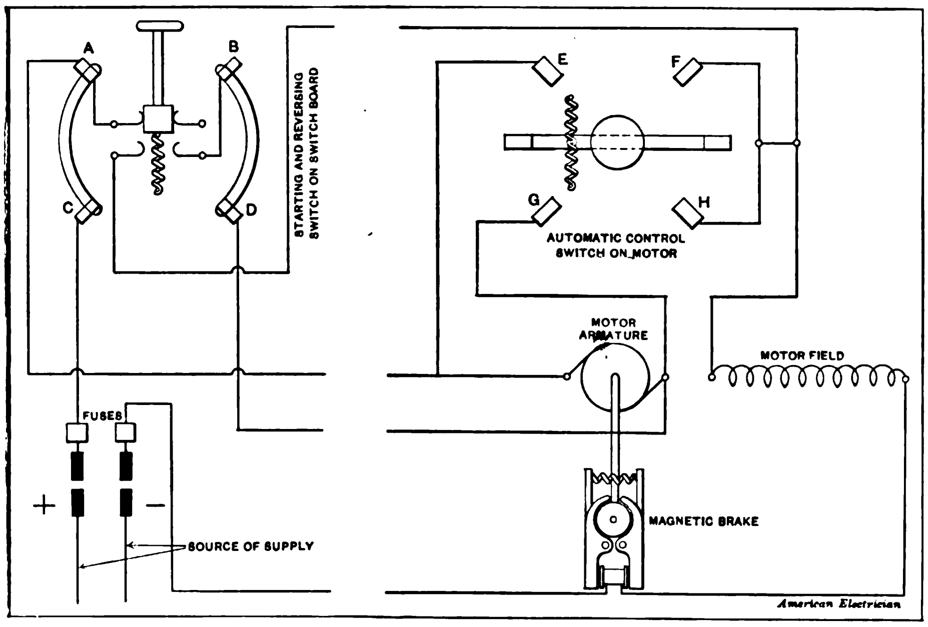
THE MOTOR-CONTROL CIRCUITS OF END-CELL SWITCHES.

In the large accumulator installations made by the Electric Storage Battery Company the end-cell switches are mammoth affairs, designed to carry several thousand amperes with removable contacts capable of traveling 10 or 15 feet over a long row of stationary contacts connected to the cells. The movable contacts are driven by screws rotated by small motors which are controlled by means of switches at the main switchboard, which is frequently some distance away.



THE CIRCUITS OF AN END-CELL SWITCH MOTOR.

Each motor is connected to its source of supply by an ingenious arrangement of switches and contacts to prevent the stopping of the end-cell switch in any intermediate position between a full and square bearing on the contact from one end cell and a similar bearing on the next. The circuits of this controlling apparatus are shown above, the apparatus to the left being upon the switchboard in the dynamo room and that to the right upon the end-cell switch, the four wires between these two locations being shown discontinued to indicate the distance between them.

The device termed a "starting and reversing switch" on the switchboard consists of a dial which can be rotated by hand between two positions, one of which connects A to C and B to D, while the other connects A to B and C to D. At the middle of this dial is a push button which, when pushed in, closes a contact between B and the wire running out to the field of the motor on the end-cell switch. The device termed an "automatic control switch on motor" consists of a cam which moves the horizontal switch arm into the position, G F, when the motor commences to turn in one direction, or into the position, E H, when the motor commences to turn in the other direction, the centering spring restoring the switch lever to the position shown whenever the motor has turned a sufficient amount to bring the brushes of the end-cell switch squarely and centrally upon a contact. The operation of the device is as follows:

Assuming that it is desired to raise the voltage one step, the rotary switch upon the board is turned as shown, so as to connect A to C and B to D. Current then enters from the positive side of the source of supply, passes through point C, point A, to and through the motor armature, back to point D, thence to point B and to the push button. If this is momentarily pressed in, the circuit is closed and the current continues through the motor field and magnetic brake, releasing the latter and starting the motor. As soon as this occurs the cam on the end-cell screw mechanism moves the automatic-control switch to the position, G F, short circuiting the push button and allowing the motor to continue rotating—even after the push button is released—until the laminated brush of the end-cell switch bears centrally upon the next contact, when the cam flies back and the motor stops. To lower the voltage the dial switch is swung around until the connections are made from C to D and from A to B; the current then passes from the positive side of the source of supply to C, to D, to and through the motor armature in the opposite direction from that previously taken, to A, to B, to the push button, and, when it is closed, to the motor field and magnetic brake, in the same direction as before, releasing the motor and starting it in the opposite direction. This throws the automatic-control switch to the position, E H, the motor continuing in operation after the push button is released until the next contact is reached by the rotation of the screw driving the end-cell switch.

A very brief closing of the push button starts the apparatus, when it continues of itself and stops at the right point. The continued holding of the button allows the end-cell switch to travel from cell to cell until the button is released.

◆

SELECTIVE TELEPHONE SIGNALS.

BY H. S. WEBB.

About two years ago Whittemore, Barrett and Craft patented a system whereby any one, but only one, of eight telephone subscribers connected across the same pair of wires, and the earth as an auxiliary circuit, could be called up. This system requires at each station two relays, either two polarized relays or one polarized and one ordinary or so-called neutral relay, responsive to currents through its coils in either direction, and a vibratory bell and battery in a local circuit.

Fig. 6, page 32, of the American Electrician for January, 1899, is a diagram of connections for eight stations; S_1, S_2, S_3 etc., are the subscribers' stations from which two wires, A and B (the outgoing and return conductors of a metallic telephone circuit), run to a central exchange, at which is located a system of eight calling keys, C, a separate key for calling each subscriber. The dotted line represents the auxiliary earth circuit.

In the same patent was described a method for placing six subscribers on the same arrangement of line wires and ground circuit, but with an additional electro-magnetic device for locking the apparatus at all the subscribers' stations except at the one called, and for unlocking all the instruments when the subscribers are through talking. Fig. 1, page 81 of the American Electrician for February, 1899, is the diagram of connections for six stations with the electro-magnetic locking and unlocking device at each subscribers' station. This whole system was quite thoroughly described in the American Electrician for January and February, so I will say no more about it here, but go on to describe a new selective signalling system which has recently been patented by J. A. Barrett.

In this patent he claims to accomplish the same results, but with much simpler apparatus at the subscriber's station. In this new system a single polarized bell, which has one or two windings on each of its two cores, has replaced the two relays, local battery and vibrating bell. The current combinations used for the selective signalling, when there are eight subscribers on the one circuit, are exactly the same as in the 1897 patent.

By the aid of Fig. 1 the principles upon which the proper combinations of currents and circuits are based can be readily understood. Let there be two metallic conductors, A and B, and an auxiliary earth circuit as shown, which is practically equivalent to three wires between C and S. It is evident that the following combinations of currents may be sent from the battery at C to S through the two live wires and the earth. A current may be sent in either direction over A, using the earth as a return and not using B at all, thus giving two selective signals. Similarly, a current in either direction may be sent over B without using A, giving two more selective signals. Without using E a current may be sent in either direction over A and B in series. This gives two more signals. And finally a current may be sent in either direction over A and B connected in parallel, returning through E, giving the last two signals. In all there are eight combinations, which are tabulated in the accompanying table.

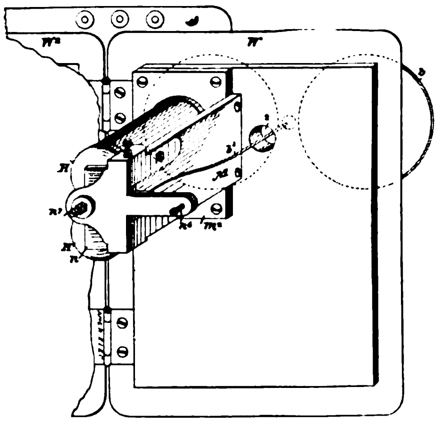


FIG. 3.—PERSPECTIVE OF BELL.

Current.			
	Line A.	Line B.	Ground.
1	+	O	—
2	—	O	+
3	O	+	—
4	O	—	+
5	+	—	O
6	—	+	O
7	+	+	—
8	—	—	+

The principle of the polarized bell employed at each station may be understood by a consideration of Fig. 2, where M is the permanent steel magnet to one end of which are attached the two soft iron cores m m, and at the other end the soft iron armature n is pivoted. It is evident that if S and N are the south and north poles respectively of the permanent magnet, M, that the lower ends of both cores will have south polarities and that part of the armature opposite the cores will have north polarity. Consequently the armature is normally attracted by both cores. Coils are wound over both cores and so connected that with a certain circuit and current combination which will operate only one bell, the normal south polarity of the lower ends of both its cores will be reversed, causing the armature to be repelled. To cause a repellant or backward movement of the armature it is not sufficient to reverse the polarity of one core or to weaken both cores, but the polarity of both cores must be reversed together.

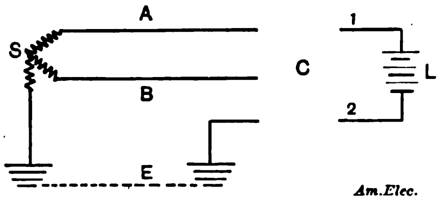


FIG. 1.—DIAGRAM OF PARTY LINE SYSTEM.

The practical form of the bell as used is shown in Fig. 3 and Fig. 4. H H are the electro-magnets, each consisting of a soft iron core, m. with one or two coils wound over it to excite or modify its magnetization; m² is an iron yoke to which is fastened both cores and the south pole end of the permanent magnet M; n is an iron armature attached through the pivots n² and bracket n⁴ to the north pole of the permanent magnet, M. Thus the cores and armature have the polarities as shown and described by the help of Fig. 2. The tension of the flat spring n⁵ operates against the normal attraction between the armatures and cores, so that by means of it and the screw, n⁶, the sensitiveness of the bell may readily be adjusted. This spring generally acts in opposition to the magnetic attraction; but it is adjusted to such a tension that its operation imparts promptness to the responsiveness of the armature to repelling forces and does not hinder the return of the armature to its normal position when the normal polarity of the cores is restored.

Now, when a current passes through the coils in such a direction as to reverse the polarity of both cores, one gong of the bell will be struck by the hammer, and when the current is broken the armature will return to its original position and the other gong of the bell will be struck. Thus the bell may be made to give a continuous ring by alternately making and breaking the current through the same particular combination of circuits.

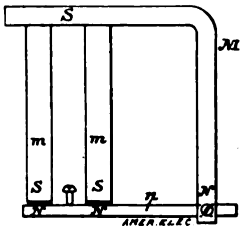


FIG. 2.—POLARITIES OF BELL CORES.

Fig. 5 illustrates a party line circuit with eight subscribers. O is the central station and Z, Z², Z³, etc., are the subscribers' stations. Two main line conductors, A B, extend from the central office to all the subscribers, and at each subscriber's station, at E² and at the central office at E, there is a connection made with the ground. At the central office there is an ordinary alternating current generator, G², such as is used for ringing magneto bells. It supplies current to the coils of D, a sort of polarized relay, arranged to make and break at X the circuit of a battery or direct-current generator, G. There is also at the central office a bank of eight signalling keys. Key 1 represents subscriber Z, key 2 subscriber Z², and so on, and when any one key is pressed only the corresponding subscriber will be rung up. Thus with key 1 there are connected a branch wire, v, from the main conductor, A, a branch, e, from the conductor, C, running to earth, and branches y and z from the plus and minus poles of the battery, G, and, when this key is depressed, the branch, v, of the main conductor, A, is brought into contact with the branch, y, of the battery conductor, I, and the branch, e, of the earth connected conductor, C, into contact with the branch, z, of the battery conductor, J. As a result of this operation a current flows in a positive direction over the main conductor, A, and returns through the earth. Key 2 operates the same set of circuits, but reversely; that is, it sends a positive current out through the ground to the subscribers and it returns through the main conductor, A, thus causing the current through A and the subscriber's apparatus to be reversed in direction. In keys 3 and 4 branches, r, from the main conductor, B, replace the branches from conductor, A, and thus when these keys are manipulated the currents are plus and minus, as with keys 1 and 2, but they flow through the main conductor, B, instead of through A. Keys 5 and 6 have no connection with the earth and are so connected by branches v and r with both main conductors A and B, so that when 5 is closed a positive current goes out over A and returns through B, and when 6 is closed a positive current goes out over B and returns through A. Keys 7 and 8 are connected to both main conductors A and B and to the grounded wire, C, in such a manner that closing key

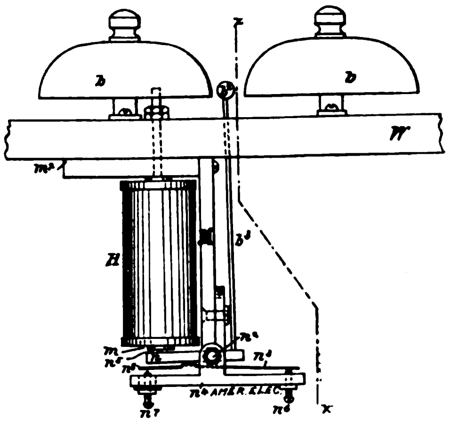


FIG. 4.—PLAN OF BELL.

7 sends a positive current out over both conductors A and B in parallel, returning through the earth; closing key 8 sends a positive current through the earth, returning through both main conductors A and B. The circuit combinations made by closing the several keys respectively cause the resulting currents in the main conductors and the earth to be the same as shown in the table given above.

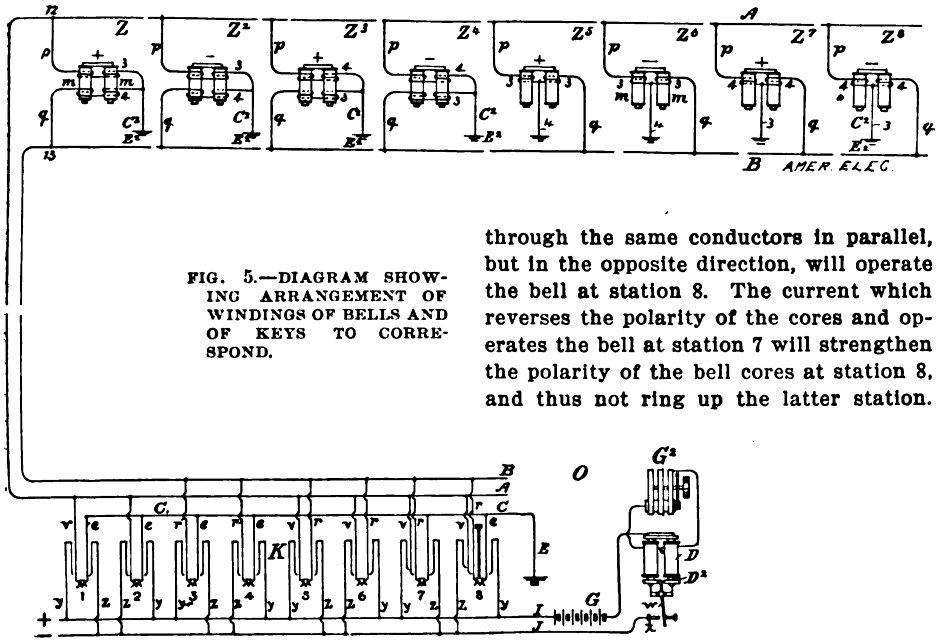


FIG. 5.—DIAGRAM SHOWING ARRANGEMENT OF WINDINGS OF BELLS AND OF KEYS TO CORRESPOND.

At the first and second stations, Z and Z^2, the cores, m, m, of the polarized bells are wound with two sets of coils 3 and 4. One set, 3, wound around both cores in the same direction, is connected to the conductor, A, and the ground, E^2, while the other set, 4, wound around both cores, but in opposite directions, is connected to the conductor, B, and the ground, E^2. The sole difference between stations Z and Z^2 is that coils 3 are wound in opposite directions around their respective cores, so that a current through coils 3 will reverse the normal polarity of the cores, m, at Z, will strengthen the normal polarity at Z^2 and vice versa. The same is true of the apparatus at stations Z^3 and Z^4, except that at these stations the set of coils, 3, are connected between the conductor, B, and the ground, E^2, and the set, 4, which pass around the cores in opposite directions are connected between conductor, A, and the ground, E^2.

At station Z^5 there is but one set of coils, 3, which is wound over both cores in the same direction, and at station Z^6, the one set of coils, 3, is wound over both cores in the same direction, but at station Z^6 the set of coils, 3, is wound in the opposite direction to the set, 3, at station Z^5. A current passing from conductor A through both coils in series at station Z^5 and returning through B will reverse the polarity of both cores and so operate that bell, but this same current passing through both coils in series at Z^6 will strengthen the normal polarity of both cores, so that the bell at Z^6 will not ring. Similarly a current which will ring the bell at Z^6 will not ring that at Z^5.

At each station, 7 and 8, there is likewise but one set of coils, but so wound at 7 that a positive current over both A and B in parallel, returning through the earth, will ring up that station, and a current through the same conductors in parallel, but in the opposite direction, will operate the bell at station 8. The current which reverses the polarity of the cores and operates the bell at station 7 will strengthen the polarity of the bell cores at station 8, and thus not ring up the latter station. Similarly a current which will ring up station 8 will not ring the bell at station 7.

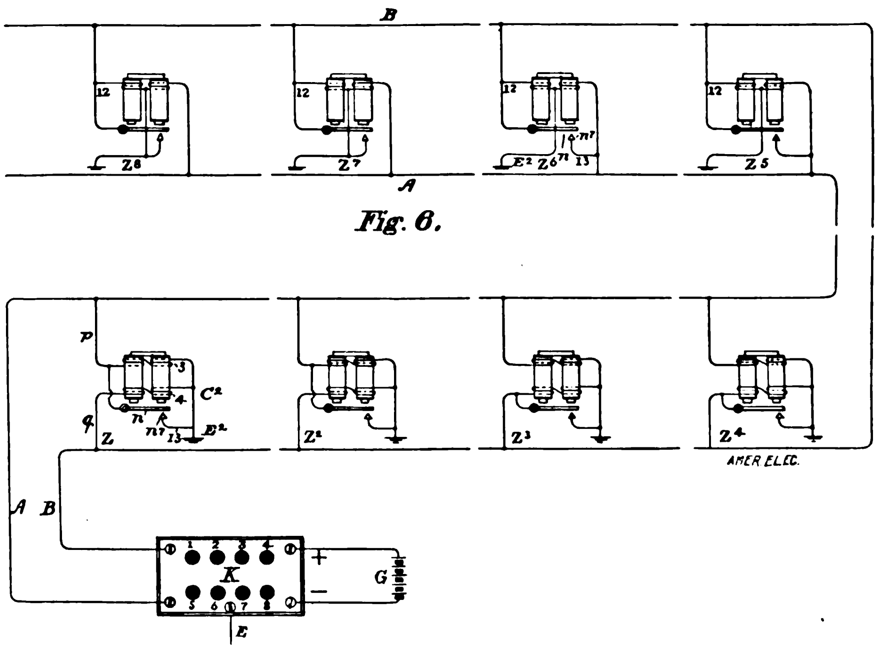


FIG. 6.—CIRCUIT WITH SHORT-CIRCUITING DEVICES ON BELLS.

The current which operates the apparatus at station Z by reversing the polarity of both cores will not operate that at station Z^2, because it tends to strengthen the normal polarity of both cores there. Neither will it ring up stations Z^3 or Z^4, because there, though it passes around both cores, it acts to reverse one core only. Furthermore, it cannot operate the bells at the remaining four stations, because at each it only circulates in the winding of one of the cores, and hence has no action whatsoever on the other. The same reasoning applied to the currents which operate the bells at Z^2, Z^3 and Z^4 shows that these currents cannot ring the bells at any other station. The current circulating through both mains A and B in series to operate the bells at stations Z^5 and Z^6, according to its direction, neutralizes its own action in stations Z to Z^4, because in each, while it passes around the cores in one set of coils in the proper direction to reverse them, it also passes around them through the other set of coils in a direction adapted to sustain the normal polarity of one core and to reverse that of the other, the combined effect will not repel the armature. So, also, as regards stations Z^7 and Z^8, these currents are adapted to reverse the polarity of one core and reinforce that of the other. These stations are, therefore, also irresponsive. And the current circulating in both conductors A and B in parallel to operate the bells at Z^7 or Z^8, according to its direction, for like reasons cannot operate that of any other station; for, as may easily be traced, it does not at any other station pass through the coils of both sets in such a direction and in such a manner as to cause a reversal of their magnetic polarity simultaneously.

At the present time most central stations are equipped only with alternating-current generators for ringing purposes, and it might be quite advantageous to use this same ringing current on a selective party line system. This can be done for four subscribers by this system. The apparatus utilized would be that at stations Z, Z³, Z⁵, and Z⁷, and the four corresponding keys, 1, 3, 5 and 7, at the central office, O, where the terminals of the alternating generator, G², would be connected directly to the conductors, I and J. The battery, G, and polarized relay, D, would not be needed. A little consideration would show that an alternating current having line A and the earth for its circuit will operate only station Z. For station Z³ requires a current through line B; station Z⁵ a current through both lines A and B in series; station Z⁷ a current through both lines A and B in parallel and the ground, in order to operate the bell apparatus at each respectively. Similarly it can be shown that an alternating current through any one of the remaining three combinations of circuits will ring up only one station.

Mr. Barrett says he finds it more satisfactory under practical conditions to have the make and break in the circuit for interrupting the direct current localized at each subscriber's station instead of at the keys at the central office, so that a continuous current and not an interrupted one may be sent out from the central office when any key there is closed. The usual circuit breaking device of the ordinary vibrating bell may be used for this purpose, but he has devised a self shunting device which he says is preferable.

The system equipped with this short circuiting or shunting device is shown in Fig. 6.

Each bell apparatus is provided with a normally open shunt circuit around one or both of the active coils on the cores and a vibratory circuit changer operated by the movements of the armature and acting automatically to close the shunt and to short circuit the coils when the armature is repelled. Thus the working current is withdrawn from the coils without breaking the circuit, which will cause the cores to resume their normal polarity, thereby attracting the armature, opening the shunt, and readmitting the current to the coils. This operation, which is rapid and vigorous, is repeated as long as the same key is kept closed at the central office, O. Thus while the current through the active coils is interrupted as required, the currents in the main circuits are not interrupted, but remain almost continuous.

The keys, K, in Fig. 6 are arranged exactly as those in Fig. 5, the only difference in the central station apparatus between the systems shown in Figures 5 and 6 is that no alternating current generator, G². or polarized relay, D, are required for the latter system as for the former.

Good results have been obtained in both systems, so Mr. Barrett says, by providing a total resistance in the bell magnet winding at each station of one thousand ohms, so arranged that in the bell apparatus of the first four stations there are four windings of two hundred and fifty ohms each, and in the others two windings of five hundred ohms each.

SEPARATING OIL FROM FEED WATER.

In addition to the well-known appliances for extracting oil and grease—and water—from water which is to be pumped into steam boilers, there are several more or less efficient arrangements for taking out oil, which are home made, and may be arranged by the engineer with but little cost save for time and trouble. Two of these arrangements will be discussed in this article, and a future article will deal with the purification of feed water in various ways. But before proceeding to the home-made appliances there remain a few more grease extractors which have not been described in the preceding articles.

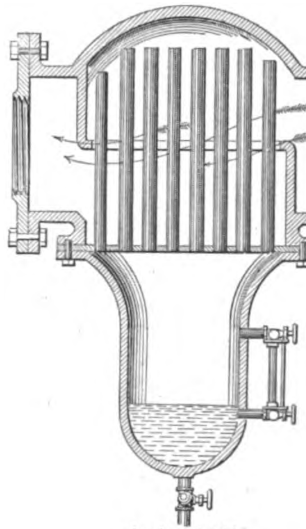


FIG. 1.—KIELEY OIL EXTRACTOR.

Of the tubular oil and grease extractors only one variety will be described owing to the lack of space. That shown by Fig. 1, made by Kieley & Muller, New York, has a series of vertical tubes which collects the water or grease and carries it down to the bottom of the containing vessel. This is also a side-port separator, and seems to be a well-arranged appliance.

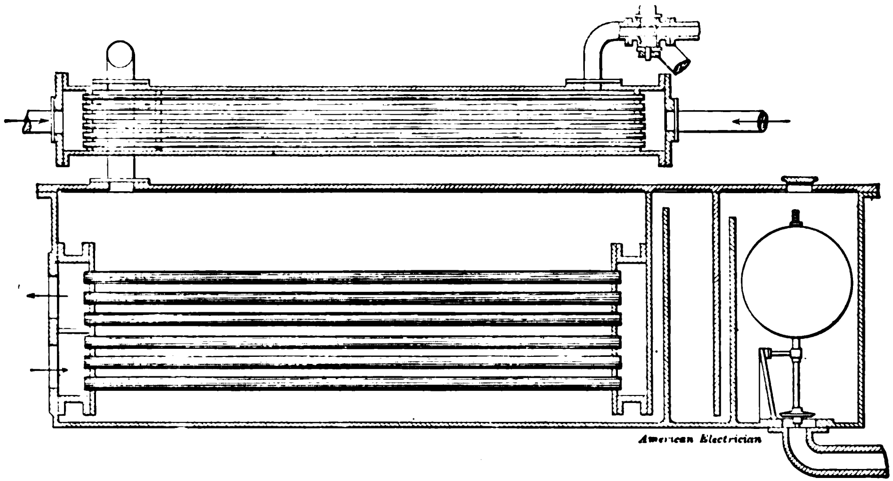


FIG. 2.—HOOKER'S GREASE EXTRACTOR.

In the tubular grease extractor shown by Fig. 2 the construction is radically different. The tubes are horizontal, and the water of condensation, after being cooled by the feed water circulating inside of the tubes and purified by the extraction of grease, passes out of the lower right-hand outlet of the separating tank into and through the tubes of the upper tank, where it is again heated by the hot water circulating around outside of the tubes, finally passing to the boilers through the pipe at the left-hand end of the heater.

The float valve shown remains open as long as there is a free supply of water to the separating tank. This device was invented by William R. Hooker, Jersey City,

Fig. 3 shows a form of separator different from any heretofore illustrated in these articles. The difference lies in the fact that the device is reversible, and therefore the impurities abstracted from the oil may be washed out by simply reversing the current of steam through the device.

Turkish toweling is used as the filtering medium, made in the form of a bag, and drawn over a skeleton of circular bronze sections. The area of the toweling is from 250 to 1000 times that of the feed pipe, consequently a very slow velocity is maintained in the flow of the steam through the device.

There is an ingeniously-arranged bypass in this valve whereby the flow may be cut off from the filter proper and allowed to pass through the device while the toweling is being cleaned or replaced. By another variation of the valves the current may be reversed through the filter, as already described. These filters are made by the Ross Valve Company, Troy, N. Y.

Two appliances of somewhat similar appearance are shown by Figs. 4 and 5. The first, Fig. 4, represents the Cookson device, which is practically a combination of feed-water heater, purifier, oil separator and filter. The oil is separated by the baffle plate and reverse of current principles. The water, entering the spray box at the top of the filter, overflows in a spray to the pan below, and the overflow from this pan falls into the next, through the center, and so on through the entire number. After the water is heated it passes through a coke-filled filter chamber, then into two oil-separating chambers which are connected by means of a small pipe. This appliance is manufactured by the Bates Machine Company of Joliet, Ohio.

Fig. 5 shows another "Oil Separator, Purifier and Oil Filter," in which there is a scum pan for removing the coarsest impurities and a bed of filtering material for taking care of the oil and other impurities that may be in the oil. This appliance, which is made by the Stewart Heater Company, Buffalo, N. Y., has a sort of jet-condenser arrangement whereby the steam is brought in contact with a stream of cold water as soon as the vapor enters the steam space of the device, which is ample. The cold water supply is regulated by a self-draining float in such a manner that the cold water supply is cut off as the water rises in the shell of the device.

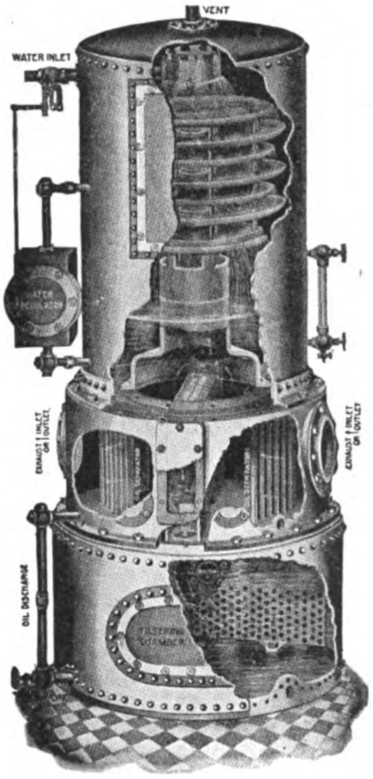

VENT
WATER INLET
EXHAUST INLET OR OUTLET
EXHAUST INLET OR OUTLET
OIL DISCHARGE
FILTERING CHAMBER

FIG. 4.—COOKSON'S FILTER AND OIL SEPARATOR.

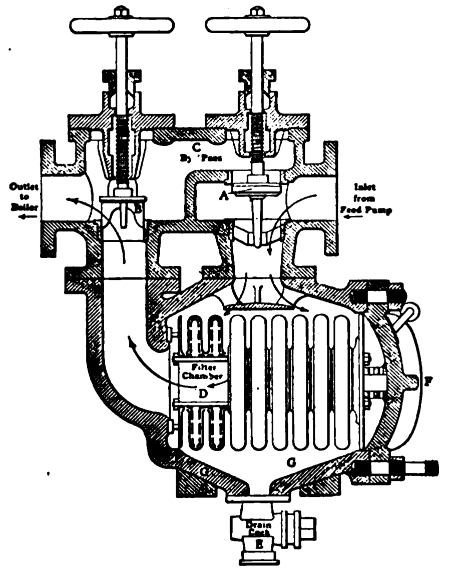

C
By Pass
Outlet to Boiler
Inlet from Feed Pump
A
B
Filter Chamber
D
F
G
G
Drain Cock
E

FIG. 3.—REVERSIBLE OIL SEPARATOR.

Still another oil separator of this class, made by the Harrisburg Pipe Bending Company, Harrisburg, Pa., is illustrated by Fig. 6. This is "The Excelsior Combined Feed-water Heater, Purifier, Filter and Oil Separator." It is claimed that this device can be very readily cleaned, and that the arrangement is such that it will clean out of the water, without use in an independent separator, practically every particle of oil, and also keep back all impurities that can be precipitated with exhaust steam.

In this arrangement, the filtering chamber is at the bottom, above it a water chamber, then a settling space, and in the top, above the central water passage is the spraying device. Some of these appliances are also equipped with traps to accommodate the return from a heating system.

Another instrument combining principles of expansion, change of direction and extraction by use of baffle plates is the Utility combined exhaust muffler tank and oil separator, a section of which is shown in Fig. 7. The steam enters through the left-hand pipe which is the inlet, and its velocity is reduced in proportion to the increase of area, therefore muffling its sound without back pressure. At this point the heavy particles of oil are precipitated by gravity. There may be seen in the illustration a series of chains riveted on angle-iron frames, which can readily be taken out for cleaning purposes—although practice has shown that this is rarely, if ever, necessary. These are so arranged as to completely separate the steam and water and to offer a large separating surface on which the oil impinges and runs down to the large receiving chamber from which it is immediately trapped away, thereby obviating the tendency of the steam to carry it up again into the system. This machine is made by the Standard Steam Specialty Company of New York City, the makers guaranteeing it to extract from 95 to 98 per cent. of oil and claiming that chemical anaylsis has shown an extraction in one instance of 99.54 per cent.

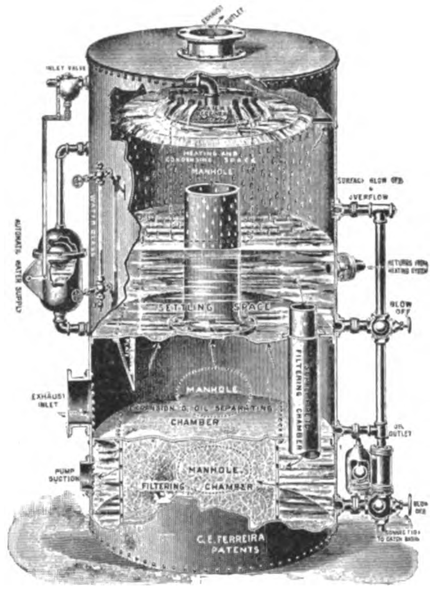

EXHAUST OUTLET
INLET VALVE
HEATING AND CONDENSING SPACE
MANHOLE
WATER GLASS
AUTOMATIC WATER SUPPLY
SURFACE BLOW OFF & OVERFLOW
RETURNS FROM HEATING SYSTEM
SETTLING SPACE
BLOW OFF
MANHOLE
EXPANSION & OIL SEPARATING CHAMBER
FILTERING CHAMBER
EXHAUST INLET
OIL OUTLET
PUMP SUCTION
MANHOLE
FILTERING CHAMBER
BLOW OFF
CONNECTION TO CATCH BASIN
C.E. FERREIRA PATENTS

FIG. 6.—EXCELSIOR COMBINATION SEPARATOR.

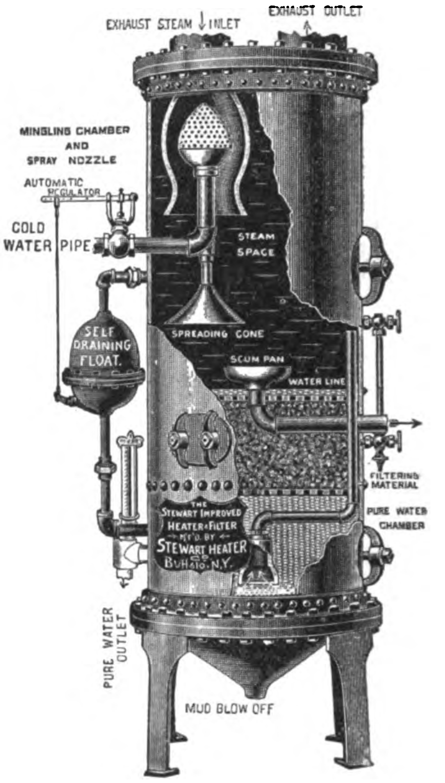

EXHAUST STEAM INLET
EXHAUST OUTLET
MINGLING CHAMBER AND SPRAY NOZZLE
AUTOMATIC REGULATOR
COLD WATER PIPE
STEAM SPACE
SELF DRAINING FLOAT
SPREADING CONE
SCUM PAN
WATER LINE
FILTERING MATERIAL
THE STEWART IMPROVED HEATER & FILTER MF'D. BY STEWART HEATER CO. BUFFALO, N.Y.
PURE WATER CHAMBER
PURE WATER OUTLET
MUD BLOW OFF

FIG. 5.—THE STEWART IMPROVED HEATER, PURIFIER, OIL SEPARATOR AND FILTER COMBINED.

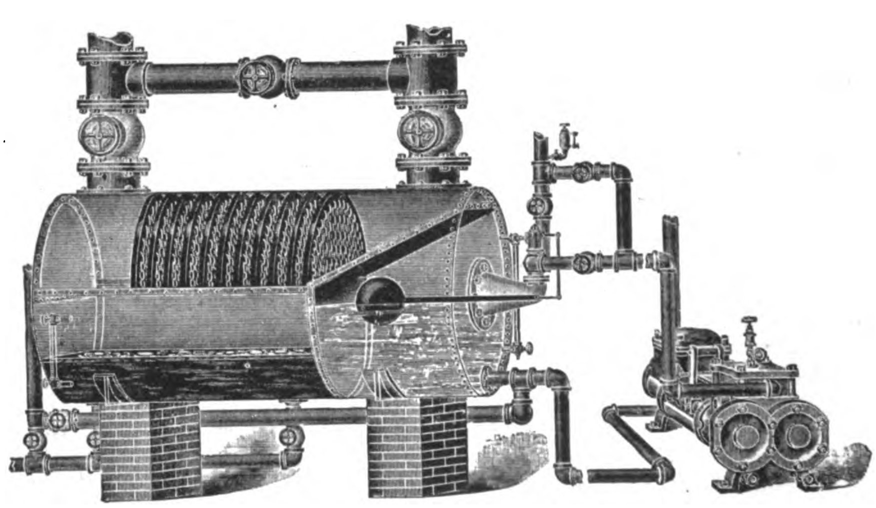


FIG. 7.—THE UTILITY COMBINATION.

Fig. 8 shows a cross section of the Wass Grease, Air and Mud Extractor. It is made by the Railway and Steamship Supply Company, New York, for whom Thornton N. Motley & Co., are the sole agents. It will be noted that this extractor works on the reverse current, baffle-plate theory, and that there is also an air-ball float which discharges all the air which would otherwise enter the boiler with the feed water. In the catalog of this extractor, it is claimed that the air entering a steam boiler causes pitting of the internal surface of the tubes and shell, also that air forms a strata above the steam, and, being lighter than the watery vapor, and also a poorer conductor, forms a strata above the ebullition line where by its tension it causes foaming or priming which continues until the air is carried into the cylinder.

Fig. 9 shows a home-made oil-extracting system, for a description of which we are indebted to "Power." In operation, this is somewhat like that described above (The Wass), and works in much the same manner. This system was invented by Mr. Amos Andrews, superintendent of the Plainfield Water Co., Plainfield, N. J., for separating the oil from the exhaust steam and making the condensed exhaust available for boiler feed purposes and also recovering the oil so that it may be used again. The system is in operation in the plant of the Water Company and the Plainfield Electric Light Co., where in each case it has given the most satisfactory results.

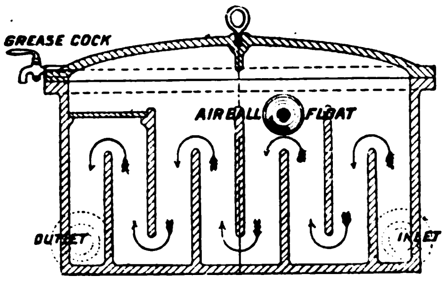


FIG. 8.—THE WASS GREASE EXTRACTOR.

The operation of the system is as follows: The engine exhaust enters the surface condenser, A, is drawn into the vacuum pump, B, and is forced through the discharge pipe into the top of tank, C. Tanks, C, D, E and F, are connected by pipes near the bottom. The last three tanks have wooden partitions as shown, extending from the bottom to within 10 inches of the top, to act as baffle plates to prevent the water flowing across the bottom of the tanks from the inlet to the outlet without circulating in each. Five inches from the top of each tank is a nipple with a freely working elbow on its outer end into which is screwed a pipe about 5 inches in length, which is kept in a vertical position over a wooden trough, G, extending the length of the four tanks. Once a week these elbows are turned down so as to drain off the oil which has collected on the surface in the tanks. This oil then runs from the trough into barrel, H, together with some water which is carried with it. An elevation of this barrel is shown to the left, where it will be seen that the water is allowed to escape through the waste pipe on the left, while the oil remains in the barrel, and may be drawn off through the cock on the right by simply turning the waste pipe about its freely moving elbow until oil commences to show, when the cock can be opened.

The water is now pumped from the bottom of tank, F, by means of the feed pump, I, through the coil in the heater, J, and thence to the oil separator, K.

The feed-water enters the separator as shown. The discharge pipe to the boilers, being near the bottom, the water now descends very slowly, owing to the large diameter of the separator, thus giving the oil a chance to remain at the top, where it finds its way into the oil chamber, L, displacing what water may be in its way. The water in the separator being heated to a high temperature—the heavy oil is precipitated and rises to the oil chamber. Once in this chamber the oil is not liable to be stirred up and mingle with the feed water. From the top of the oil chamber a pipe is brought down and has a valve at its lower end, by means of which the oil is drawn off.

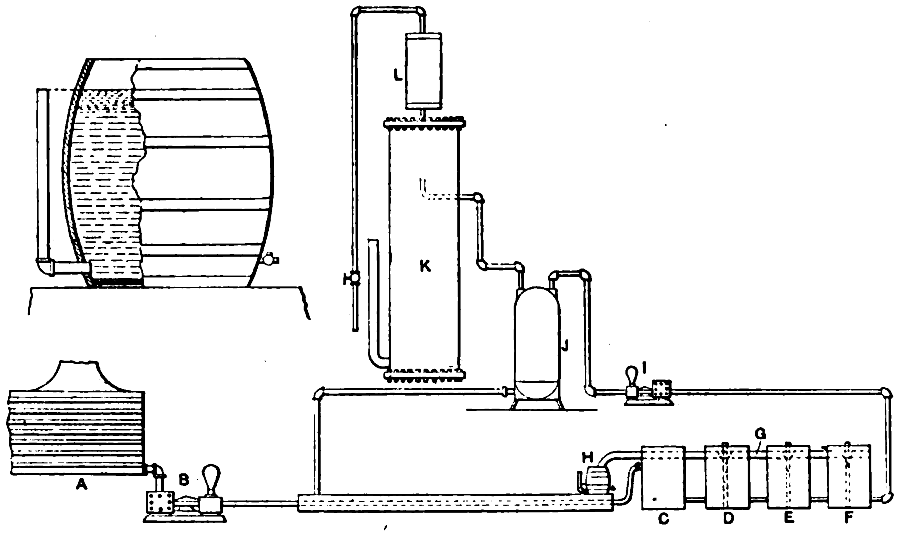


FIG. 9.—ANDREWS HOME MADE SEPARATOR.

In the next paper, the matter of feed-water purification will be taken up, and several forms of apparatus described for that purpose, ranging from the home-made "tank" system, to elaborate machinery for that purpose, and to the chemical treatment necessary for throwing down feed-water impurities before they are pumped into the boiler.

Letters on Practical Subjects

Aluminum Cable Sheaths.

To the Editor of American Electrician:

Sir.—With reference to the last paragraph of your editorial in your last issue, relative to concentric cables, this subject which you bring to our attention is entirely new, and, needless to say, is very interesting.

It would be quite possible to squirt aluminum the same way that lead is squirted to form a covering for cable. We are inclined to doubt the ability of ordinary lead presses, however, to squirt aluminum, on account of the double fact that aluminum would require somewhat higher heat to render it plastic than is required with lead; and, secondly, because the power required to squirt aluminum would be more than what would be required to squirt lead. Aluminum has been, however, successfully squirted, and we are, ourselves, building a squirting machine for an altogether different purpose, but with which we intend to squirt large sections of aluminum.

As to the flexibility of aluminum, in this respect the aluminum would be, of course, inferior to the lead, but we see no reason why it should not be flexible enough to answer the purpose. In fact we are inclined to think, taking ordinary lead-covered cable, the stiffness of which is made up by the cable, the insulation of the cable, and the lead sheath, that the additional stiffness imparted to such a cable by the use of aluminum sheet would be but of a very slight percentage.

We are inclined to think also that the difficulty of making a soldered joint would not be an obstacle. Whereas aluminum cannot be soldered with ease, and we do not recommend soldered joints where great tension is to come on the joint or where the joint must be water tight, or anything of that sort, nevertheless a good joint can be made for electrical purposes. We have sold a great many street railway feeders recently where the cables were soldered together in a sleeve the same as copper cables are done. In fact the Northwestern Railway of Chicago, a description of whose plant you have published, soldered all the aluminum cables they used.

The Pittsburgh Reduction Co.,
Arthur V. Davis,
General Manager.

Pittsburgh, Pa., Jan. 12, 1900.

Electrical Catechism

395. To what extent can the speed be regulated by changing the resistance of the armature circuit?

The speed may be reduced to any amount desired by putting enough resistance in series with the armature. This is not economical, however, for all the pressure lost in the resistance (when multiplied by the current) represents lost energy wasted in heating the resistance. The speed increases as the resistance is cut out from the circuit and the upper limit is reached when all the adjustable resistance is out.

396. How can the power delivered by a motor be increased?

The power equals the product of speed by torque or pull. Either or both of these may be varied by changing either the voltage at the terminals of the armature or by changing the effective number of magnetic lines of force through the armature.

397. How can the effective number of magnetic lines of force through the armature of a motor be changed?

Either by shifting the brushes or by changing the number of ampere turns in the field magnet coil. As a general rule, it is not advisable to shift the brushes far from the neutral plane, lest excessive sparking damage brushes and commutator.

398. How does a change in the effective number of magnetic lines of force through the armature affect the torque in the case of a motor on a constant current circuit?

The torque is proportional to the product of current by armature wires by lines of force. (See Nos. 332 to 335, Amer. Elec., XI., 432, Sept., 1899.) In a constant current circuit, such as an arc light line, the effective number of armature wires or the effective number of lines of force may be varied to some extent by shifting the brushes. The total number of lines of force may be varied by changing the number of ampere turns through the field coil. The latter may be varied either by connecting a shunt of variable resistance around the field coil or by having a number of terminals so that the part of the coil may be cut out.

399. How does a change in the field affect the torque of a motor on a constant potential circuit?

The effect in such a case is more complicated than in the preceding case, for a change in the field affects the current and both the speed and the torque are apt to change in consequence. With a given current, the torque would be increased by strengthening the field; but the stronger field increases the c. e. m. f. for the same speed, and this reduces the current. Under ordinary conditions it is found that strengthening the field of a motor on a constant potential circuit causes a more than proportional decrease of current. The result is that within the limits met in ordinary practice, the torque and the power of a motor on constant potential circuit are actually increased by weakening the field.

400. How does a change in the field affect the speed of a motor on a constant potential circuit?

Weakening the field causes the armature to run faster. Suppose a motor has a load that takes the same belt pull regardless of the speed. Since the field is weakened, the current must increase to maintain the torque constant. This increased current causes a greater ohmic drop and so reduces to some extent the c. e. m. f. necessary to equal the balance of the line pressure. Since the field is weaker, the speed must be increased proportionally to bring the c. e. m. f. to its former value and almost that much to bring the c. e. m. f. to the new and slightly smaller value. It is difficult to show the exact relationship without using algebra, but the conclusion is that for the same belt pull the speed is increased by weakening the field.

401. What is the common method of regulating motors?

Motors on constant potential circuits are generally plain shunt motors. When it is desired to adjust the speed accurately, a rheostat is cut into the field circuit. In some cases the motor is compound wound—that is, it has two field coils, one of fine wire shunted around the armature and one of coarse wire in series with the armature. The series coil may be cumulatively connected so as to assist the shunt coil and strengthen the field as the load increases, or it may be connected differentially so as to oppose the shunt coil and weaken the field as the load increases.

402. Under what circumstances are the series coils connected differentially?

The differential series coils may be so adjusted as to maintain the speed constant at all loads by weakening the field just enough so that the c. e. m. f. at the desired speed falls just enough to equal the increased ohmic drop due to the greater current at the greater load.

403. Under what conditions are the series field coils connected cumulatively?

The series coils are connected so as to strengthen the field to the shunt coils when the motor must start under heavy load or when the load is subject to great fluctuations and when exact regulation of speed is of less importance than disturbances of the line pressure. In some cases the armature reaction weakens the field so much that the series coils must be connected cumulatively to keep the field strong enough and so maintain constant speed.

404. Why do some plain shunt motors run at almost constant speed at any and all loads?

By making the motor with very strong field the armature wires may be made fewer and consequently of lower resistance. For reasons given in Nos. 385, 386 and 387, the motor regulates more closely as the armature resistance is less. Some motors also are so designed that the magnetizing force of the current through the armature coils weakens the field just enough to maintain the speed constant at all loads.

405. Why are series motors used on street railways?

Because of their great starting power, the ease of controlling the speed, the smaller cost of winding the field magnet coils.

406. Why do series motors have greater starting power than shunt motors?

Since the whole of the armature current passes through the field coils, the magnetic field is strongest when the armature current is greatest. This occurs at the time of starting, for when the motor is standing still the c. e. m. f. is small. The torque is very great, since both the field and the current through the armature are strong. Resistance is placed in series with the motor to prevent too great a rush of current, which would start the car with an uncomfortable jerk. As the car begins to move, the resistance is rapidly cut out and c. e. m. f. replaces ohmic drop in regulating the current taken by the motor.

407. What governs the final speed of a series motor when pulling a car?

As the speed of the car increases, the c. e. m. f. of the motor increases for a given current. This reduces the current and consequently the field strength, both of which reduce the torque. The torque of the motor is used partly in accelerating the car and partly in overcoming the more or less constant resistance of the track. As the speed increases, the current through the motor decreases and its torque decreases until a balance is reached when the motor torque is just sufficient to maintain the speed of the car. The relationship of current, strength of field, c. e. m. f. and torque is complicated in such a case. In some cases the speed is further increased by shunting part of the current around the field coils or by cutting out part of the coils; in modern practice it is common to connect two motors in series at the start, so that each is subject to only half the line voltage, then to throw them into multiple, so that each is subjected to the full line pressure for increased speed.

408. How can a motor be reversed so as to run in the opposite direction?

By reversing either the field or the current through the armature, the pull is reversed and consequently the direction of rotation of the armature. If both are changed, the direction of rotation is the same as before. For this reason, it makes no difference which terminal of a motor is positive. The relative connections between the armature and field must be reversed.

Queries and Answers

I wish to make a transformer to run from 10 or 12 dry cells to ring telephone bells. I have made a vibrator which runs on one cell of closed-circuit battery and alternates a set of 40 dry batteries. I can ring bells on a 25-mile line with 10 'phones in the circuit, but I want to reduce the number of batteries if possible. O. A. J.

A transformer designed to ring telephone bells from a battery would necessarily take the form of a running machine such as the small ringing generators now on the market for use in taking power from direct-current lighting systems. Such a transformer, unless made with great care and expense, would absorb so much power that it would require an even greater number of dry cells than you are now using to make up its losses without giving any output. A better solution of your problem would be to work your vibrator with an induction coil. As you are working now you get the 40 volts or so from your batteries direct on the line as alternating currents from your vibrator. If you put these alternating currents into the primary of an induction coil you will get a greatly increased voltage in the secondary due to the inductive kick when the primary opens. By winding the secondary with a greater number of turns than the primary you will still further increase the voltage and you can run easily with 10 or 12 dry cells.

We are using No. 12 galvanized-iron wire for both line and return of a common return telephone exchange system. We are bothered very much with cross talk and should like to know what the trouble is. L. A. V.

The iron wire is satisfactory for the outgoing lines from the switchboard to the instruments, but should not be used for the common return. The latter should be of far greater conductivity. It is customary to use copper wire No. 6 or No. 8 generally covered with weatherproof insulation; the wire commonly used by central stations for arc light circuits being quite suitable for this purpose. This is for the common return only, there being but one such wire on each pole line and branch thereof.

What are the dimensions of the core, size of wire and number of turns for a Tesla coil to work with a 6-inch induction coil? What means may be used for regulating the same when supplied with alternating current? S. J. S.

Tesla coils have no cores and must be very highly insulated. One of the easiest ways of making one is to take a large cylindrical battery jar 8 inches in diameter by 12 inches long, and wind over it about 60 or 80 turns of No. 18 magnet wire. This may then be fixed to the jar by a coating of shellac. The primary should be made of 8 or 10 turns of No. 4 or No. 6 wire, made sufficiently small to slip inside the jar. The whole should be enclosed in a big earthenware tub and filled with mineral seal, linseed or transil oil. For regulation the ordinary means of choking back the current in the primary of the induction coil may be used.

How shall I connect the leads to the commutator in an L. 2 T. H. arc machine? Do they run red one, white two and blue three, and if not, how do they run? Also, what is the length to set the leading and following brushes? A. V. S.

There being only three wires it is impossible to connect them in wrong rotation. The brushes are usually set by a gauge, which is furnished with the machine. The two leading brushes should be diametrically opposite each other and the following brushes should be of such length that they will just bridge a commutator gap when the controlling magnet is in the down position. The commutator should be set so that there is a spark at the leading brush about 3/32 of an inch long. If a shorter spark is carried at the brushes the machine is likely to flash.

(1) Would 260 volts kill a man if he were directly connected between an overhead trolley wire and the rail of a street-car system? (2) What is the lowest voltage known to have killed a man? (3) What is the lowest voltage known to have killed a horse? (4) What is the most dangerous, direct or alternating current at the same voltage? H. T.

(1) 260 volts would not be enough to kill a man with any ordinary direct connection across the circuit. (2) It has been recorded in Germany that a man has been killed by 250 volts, but in that instance the conditions were ideal for a fatal shock, the man was supposed to have heart trouble and the contact was made with the bare feet on wet metal and bare hands on wet wiring. The deadliness of any shock is dependent upon the conductivity of the contact at the surface of the body. If the contact is made as good as used in electrocutions by means of saturated sponges, a comparatively low voltage will prove deadly, while with dry hands touching the conductors lightly 1000 volts or even 2000 volts is often withstood. The pressure used upon street cars, which is almost invariably 500 to 600 volts, is occasionally fatal, although on third-rail systems, such as that of the Brooklyn Bridge, New Haven & Hartford and the Chicago Elevated the men work around and frequently get connected straight across between the third-rail and the track rails without any serious results whatever. (3) Horses are more easily killed by electric currents than are men, being frequently killed by street railway voltages. As they rarely encounter any lower voltages, no instances have been recorded of deaths to horses from lower pressures. (4) Alternating current is supposed to be more deadly than direct current with the same voltage, owing to the fact that a good many times in a second it rises for brief instances to considerably higher pressures than that at which it is rated. For instance, 100-volt alternating current is really for part of the time 140 volts. Whether it is more deadly or not is a difficult matter to decide, as experiments naturally have not been made in this line.

Can first-class service be given on a 220-volt three-wire system fed at different points by fairly large transformers, fed direct from the central station, where by means of boosters the pressure on the three-wire secondaries can be kept at 220 volts? Would the above system, furnishing incandescent and arc lights on 60 cycles, give good regulation when for half the night the amount of current consumed for arc lights considerably exceeded the amount consumed by incandescent lights? Would these arc lights in multiple cause an inductive load? State the best method to operate a system of this kind. R. B. S.

First-class service can be given on a 220-volt three-wire system fed as indicated, and if as much care is taken in laying it out the regulation can be as perfect as with the same distributing system fed by direct currents. The use in every feeder of an induction booster or potential regulator, which is only possible with alternating currents, allows finer gradations of pressure to be had than can be obtained conveniently with direct currents. The only comparative disadvantage of the alternating current is likely to be the ohmic and inductive drop in the transformers, especially the inductive drop with constant potential arc lights and alternating current motors. This can be reduced by the use of transformers giving close regulation, and care should be taken that the regulation, i. e., the drop of voltage on the secondary at full load below the no load voltage, the primary voltage remaining constant, is less than two per cent. A still better way to arrange the system so that transformers of very poor regulation can be used, their drop being balanced by the potential regulator, is to put the transformers in the feeders, one transformer per feeder, each feeder running direct from the central station to the primary of its own transformer. By means of a Mershon compensator at the station, adjusted for the drop in the feeder and transformer, very close regulation can be obtained. A complete system of this kind with a secondary three-wire underground network has been laid out in St. Louis by Mr. Herbert A. Wagner. It is described completely in a paper read by Mr. Wagner before the National Electric Light Association at the 1898 meeting in Chicago, and also described fairly fully in another paper read by Mr. Wagner before the 1899 meeting in New York City last May. An abstract of the latter paper will be found in the July number of the American Electrician, on page 328. By this means the amount by which the arc light exceeds the incandescent light load would make no difference as the reactive drop in the transformers could be balanced out by the station attendant when manipulating the potential regulators. Arc lights in multiple do cause an inductive load, not that the arcs themselves possess any self-induction, but the choking coils used in series with them are invariably inductive and introduce lagging currents. Any such system should be run from an alternator of close regulation. If the machines are of such large size that composite windings and rectifiers are not used upon them, the regulation should be specified as five per cent.

THE ARNOLD MAGNETIC CLUTCH.

In the design of modern direct-coupled power plants it is frequently found desirable to arrange the generators in such a way that they may be readily connected or disconnected to the prime movers according to the exigencies of the service. This requirement of successful power station design was early realized by Mr. Bion J. Arnold, a pioneer in this field of engineering, who recognized at the same time the limitations of the ordinary friction clutch for this purpose. Accordingly, some years ago, Mr. Arnold worked out a device which would meet modern requirements, and the result has been the development of what is now generally known as the Arnold magnetic clutch, a number of which have already been built.

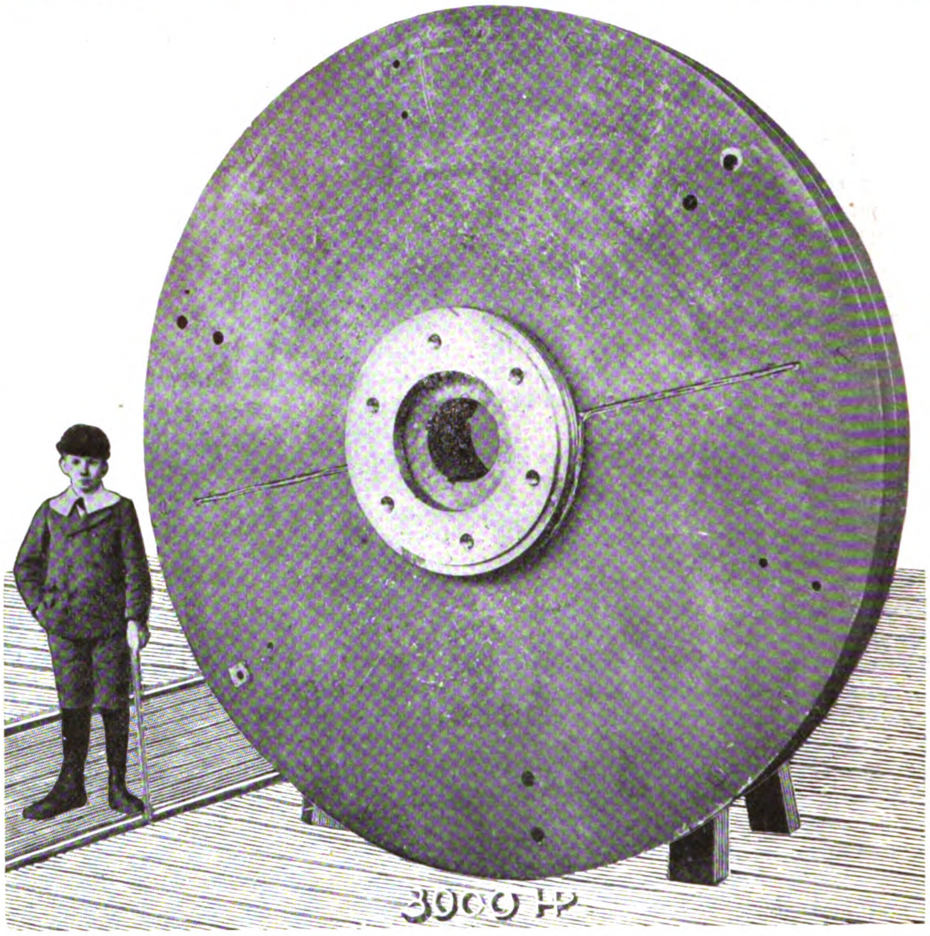
These clutches are in reality friction clutches, yet the friction between the contact surfaces is not due to mechanical pressure, but to magnetic attraction. The working parts of the clutches are composed of metal having a high permeability so arranged as to become magnetized upon the passage of direct current through the coils with which they are provided. The two parts of the clutch can be attracted together in this way with a pressure far in excess of that obtained in mechanical clutches, and it is only a question of making the clutches large enough to enable them to transmit power in any desired amount. The energizing circuit is controlled by means of a switch placed at a convenient point, which is quite a decided advantage over the ordinary friction clutch. It thus becomes possible, in throwing a generator in or out of service, to control it entirely from the switchboard, where all the regulating devices and measuring instruments are within the reach of one attendant. These magnetic clutches also possess the advantages of neat appearance and compact design. Even in the larger sizes the amount of space occupied upon the shaft is not much more than twice the diameter of the shaft, and by using a flange forged solid on the end of the shaft, they can be made to occupy even less space when used as cut-off couplings. Owing to their having no projecting surface or parts to catch the air when in operation, the windage resistance is negligible. The greatest advantage, however, of this form of clutch over others is the fact that it is self-contained—the "action and reaction" being within the clutch itself, and consequently there is no resulting end thrust upon the shaft bearings and no additional friction load due to the operation of the clutch.

The accompanying illustration shows the largest magnetic clutch in the world. It is 100 inches in diameter and is capable of transmitting 3000 h.p. at 150 r.p.m. This clutch is one of the three now in use connecting the engines and generators in the central station of the Imperial Electric Light, Heat and Power Company at St. Louis, a description of which recently appeared in these columns. The experience with this plant demonstrates that this form of clutch is applicable to the large size units now being installed for power station purposes, whereas the ordinary friction clutch becomes especially unwieldy and unsightly after passing the 500-h.p. size.

There appears to be no reason why a clutch of the type shown in the illustration cannot be substituted for the fly wheel of the engine in many cases, thus making the weight and cost of the engine unit, fitted with magnetic clutches, but little more than the weight and cost of a similar installation fitted with ordinary mechanical couplings.

The current is carried to the clutch coils through contact rings upon the ends of the clutch, and carbon brushes held by insulated brush holders. The electrical connections are simple and easily accessible for inspection.

The unique feature of this clutch is the small amount of current needed. It requires no more than would be used by four 16-c.p. incandescent lamps, and the loss in the clutch due to the continuous use of the electric current, while the clutch is in operation, amounts to only one one-hundredth of one per cent. of the power-transmitting capacity.



THE LARGEST MAGNETIC CLUTCH IN THE WORLD, DESIGNED TO TRANSMIT 3000 H.P IN USE IN THE IMPERIAL PLANT, ST LOUIS.

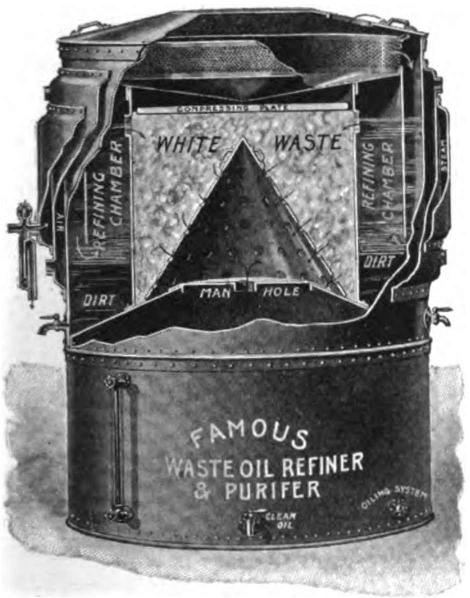
Although these clutches were developed for use in connection with the "Arnold System" of power station construction, their application is in no way limited to the demands of this system, and they have been adapted and adopted for other purposes. A number have been made to connect large synchronous motors to their load in such a way that they can be quickly disconnected in case of accident, and they have also been built for use upon line shafting. It would seem that they were particularly applicable to use in connection with gas engines, and there is no doubt an excellent field for them here. They might eliminate the fly-wheel problem of the gas engine in many cases, which of itself would be a distinct advantage. Indeed, there would seem to be no limit to their use wherever it is desired to transmit power from one shaft to another.

THE FAMOUS WASTE OIL REFINING AND PURIFYING SYSTEM.

On the yearly balance sheets of all steam engine and electrical plants the item "oil" forms a percentage by no means small of the total cost of supplies. This item can be so greatly reduced by using the same oil repeatedly that there is now no excuse for throwing away any of the lubricating oil. Great care should be taken, however, that the filtering treatment applied to the oil absolutely frees it of impurities as the pressure with which it is squeezed and rubbed in the working parts of heavy machinery tends to disintegrate the hydrocarbons of which the oil is composed and to set free minute particles of carbon. These particles are what to a large extent cause the discoloration or blackening of oil when used. As carbon is a fairly good abrasive, these fine particles grind the surfaces of bearings and slides, greatly increasing the wear.

The Famous Filter Company of St. Louis, Mo., argues that some purifying methods quite commonly used are harmful, and makes up what it terms an "oil refining and purifying system" which avoids these harmful methods. One argument is that the attempt to clean oil by washing it with either hot or cold water is certain to fail since the oil does not diffuse itself through the water, but passes through it in the form of globules or drops, which retain within them the injurious impurities, such as finely divided particles of carbon. Another argument is that the direct contact of oil with steam-heated surfaces causes disintegration of the oil through heating.

The oil-purifying system made by this company is illustrated below. The water and waste oil from the engine comes in to the separator at the right, in which the oil, dirt and water are separated into three layers by their difference in weight, as the illustration indicates. The oil passes over into the Famous waste oil refiner and purifier, appearing in the left-hand illustration. The incoming oil passes through the straining surface to a settling and refining chamber, which is divided by a shield in order to prevent the incoming oil from passing directly to the outlets into the filtering waste in the center. The oil in the refining chamber is heated by a steam jacket through an air jacket, which prevents too high a temperature being transmitted to the oil. This heating thins the oil, allowing part of the dirt to settle at the bottom of the chamber. The heat also drives off water and the more volatile elements of the oil, refining it and making it a better lubricant. The heating being applied to one side instead of below, causes less circulation and stirring up of the impurities. The finer particles are taken out by passing the oil through the waste and through a muslin cover which surrounds a perforated cone in the center.



THE WASTE OIL REFINER AND PURIFIER WITH SHELL BROKEN AWAY TO SHOW INTERIOR CONSTRUCTION.

From the waste-oil refiner the oil passes to a clean oil reservoir. From this it is drawn off as wanted for lubrication.

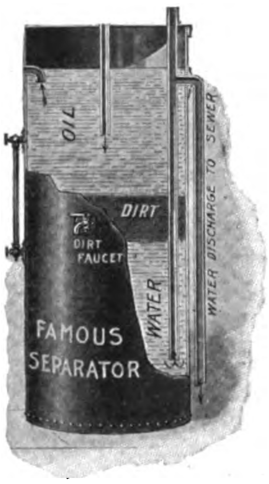
◆

ON THE USE OF OIL IN TRANSFORMERS.

A recent bulletin published by the Pittsburgh Transformer Company gives so much pertinent information on this subject that it is worthy of reproduction almost in full, as follows:

The trend of modern practice is entirely toward the use of oils in transformers. While the larger units of high voltage are dependent upon oil for insulation and cooling, it is recognized that the benefits are by no means confined to such, and the smallest lighting transformers are now operated in oil.

Perhaps the most striking effect of oil is shown in the improvement it causes in the insulation of the transformer. The table below gives the results of break-down tests of papers, the samples being tested dry and also after soaking in oil. The latter are allowed to drain until surface dry.



THE SEPARATOR FOR REMOVING THE WATER AND THE COARSER DIRT FROM THE OIL ON ITS WAY TO THE REFINER.

Paper.	Thickness.	Volts Dry.	Volts Saturated.
Bond	0.0030 in.	756	1,376
Fibre	0.0065 in.	1,000	4,040
Fibre	0.0098 in.	1,161	4,950

It will be noted that the thin hard bond paper was improved 82 per cent. while the thicker and more porous papers required a higher voltage to break them down by 304 per cent. and 327 per cent., respectively. From this it appears that the tough-fiber papers, being able to absorb oil, will stand over four times the voltage thus saturated than when dry. It has been observed that in many cases where a break down of the transformer insulation occurred, a short interval of rest would be followed by the disappearance of the short circuit, due to the oil filling the puncture and thereby reinsulating the same. The comparative freedom from damage arising from lightning or other static discharges with the later forms of oil-insulated transformers, is due in great measure to the above improvement which oil effects in the insulation, not only between the windings and layers of the same, but between the coils and the iron of the core and case.

An important feature in addition to the above is that the use of a proper oil enables a transformer to operate at lower temperatures than if it were run dry. Full-load tests of 1.5, 2, 4 and 15-kw. transformers show that the coils and core run on the average about 15 degrees F. warmer with air than with oil insulation.

An understanding of the action of the oil in cooling will indicate the necessary physical characteristics the same should possess. The oil in contact with the coils and iron becoming heated, rises while the cooler oil next the case falls to the bottom. These convective currents serve to bring the warm oil in contact with the iron case of the transformer, where it is quickly cooled. It is therefore easy to see that an oil which circulates freely is a far better cooling medium than a heavy-bodied oil which moves sluggishly. It is pertinent to point out also that the thin oil will penetrate and saturate a coil more quickly and thoroughly than the viscous oils.

Every one who has torn down old electrical apparatus has noticed how exceedingly brittle the insulating material had become. It sometimes happens that in transferring an old transformer from one location to another the jarring is sufficient to crack the brittle insulation, so that a break down results as soon as the transformer is thrown in circuit. The charring of insulation in the above manner is due to the fact that a slow oxidation goes on at the comparatively moderate temperatures assumed by electrical machinery and apparatus. If the insulating fabrics are kept from contact with the air, it is evident that owing to the absence of oxygen, this oxidizing will not occur, so that immersion in oil, accomplishing this result adds materially to the life of a transformer.

One of the disadvantages of the oil transformer was that the oil, drawn up the cables by capillary attraction, soon rotted the rubber covering of the leading in wires. The cables, acting as syphons, gradually drew the oil from the case and allowed it to drip or follow the service mains.

To prevent the leaking of oil from capillary action, and thus permit the use of the light-bodied oils, the Pittsburgh Transformer Company devised the following plan of treating the cable leads of its transformers: The cables are stripped of insulation just above the oil level, for a portion about one inch in length. This part is then poured with melted solder so that the stranded conductors become soldered into a solid piece, along which the oil cannot travel.

New Apparatus and Appliances

THE RECORDING WATTMETER OF THE FEDERAL INSTRUMENT COMPANY.

A new type of recording wattmeter for either direct or alternating circuits has been developed by the Federal Instrument Company, of Albany, N. Y., under the patents of Mr. Jesse Harris. The chief distinguishing characteristic of this new meter as compared with all others now on the American market is the fact that it is not a motor meter, i. e., a motor with a torque proportional to the load drawn through the meter is not used to drive a train of recording gears and a retarding brake.

The current, upon entering the meter, passes through the fixed coil of an electro-dynamometer (see Fig. 1) similar to the well known Siemens dynamometer. This dynamometer has no iron in its structure, so that the instrument is useful on either direct or alternating circuits. The outside, or movable coil, of this dynamometer is a potential winding with a zero-temperature coefficient connected across the circuit so as to get the impressed voltage; thus the torque is proportional to the load in watts passing through the meter.

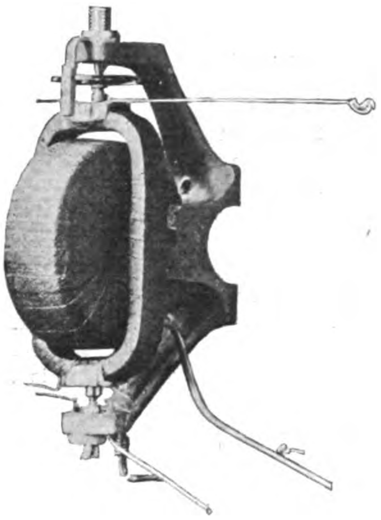


FIG. 1.—THE DYNAMOMETER OF THE HARRIS METER.

The movable coil is mechanically connected to an arm carrying a small roller which appears in Fig. 1. This roller rides between two cylinders, which are shown in the other detail view, Fig. 4. The lower cylinder, which is the driving cylinder, is revolved at regular periods by an electro-magnet, a view of which appears in Fig. 3. The armature of this electro-magnet is shown in the lower foreground of Fig. 4. This armature is attached to a pawl engaging a ratchet wheel which winds up a small spring. When this spring, which drives an accurately-adjusted balance wheel, runs down, a contact is closed through the electro-magnet across the mains, thus winding the spring up again; in this way the driving mechanism is kept in constant action.

The motion of the driving cylinder is transmitted to the upper or integrating cylinder by means of the roller carried by the dynamometer, the amplitude of the motion transmitted during each rotation of the lower cylinder depending upon the position of the roller in respect to a raised portion with which the recording cylinder is provided; this raised portion is wedge shaped, the point of the wedge corresponding with the zero or no load position of the dynamometer. An idea of the arrangement can be obtained from the accompanying diagram, Fig. 2. The lower cylinder, 12, is kept in rotation by the means described above; 13 is the roller, which is shown in the no-load position, the roller moving to the left as the load increases. In the position shown the roller just clears both cylinders so that there is no motion transmitted to the upper one. As the roller moves to the left the raised portion of the lower cylinder pushes the roller up against the upper cylinder and turns the latter by an amount proportional to the width of the raised portion, which width becomes greater and greater as the roller approaches the left-hand end of the cylinders; thus the angle through which the upper cylinder is turned during each rotation of the lower cylinder is exactly dependent upon the position of the roller, which in turn is dependent upon the torque of the dynamometer, which is proportional to the load. The upper cylinder is geared to the recording train.

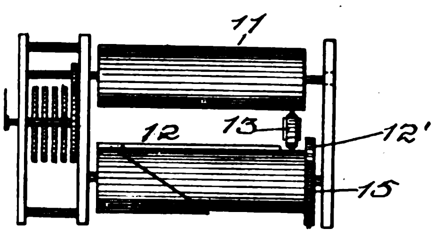


FIG. 2.—THE DRIVING AND INTEGRATING CYLINDERS OF THE HARRIS METER, SHOWING THE HELICAL RAISED PORTION OF THE DRIVING CYLINDER.

While the roller is out of contact with the cylinders, as it is for a portion of each rotation, it is frictionless and free to move under the influence of the dynamometer, so that it can take any proper position determined by changes in load. As the recording train is driven by a power entirely independent of the measuring dynamometer the latter is not impeded by friction. In fact the instrument is as sensitive at no load as at full load, and the friction of the recording mechanism does not affect its indications at all until it becomes so great as to absolutely impede the motion of the powerful driving apparatus.

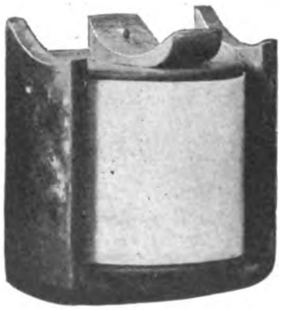


FIG. 3.—THE MAGNET FOR WINDING THE SPRING OF THE HARRIS METER.

The meter is solidly built and is constructed more on the lines of a machine than of an instrument, and should be capable of withstanding considerable rough treatment without affecting the accuracy. It is very small and compart when compared with other meters, the 100-light size being only 7¾ x 6¼ x 3½ in. in its outside dimensions.

The appearance of the complete meter in the case is surprisingly small. A name plate at the lower end covers the four binding posts, the case covering the working parts being sealed before the meter leaves the factory.

IMPERIAL ENCLOSED ARC LAMPS.

An enclosed lamp which is of interest through the perfection of its design and the care taken in the details of its construction is made by the Imperial Electric Lamp Company of New York City. A view of one of these lamps, with the case and globe removed, is given in Fig. 7.

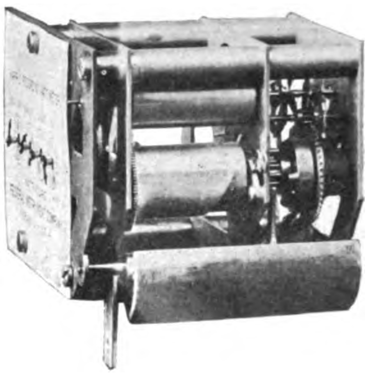


FIG. 4.—THE RECORDING DIALS, CYLINDERS AND ESCAPEMENT OF THE HARRIS METER. THE ARC-SHAPED ARMATURE IN FRONT OPERATES ACROSS THE POLES OF THE MAGNET IN FIG. 3.

To those who constantly handle enclosed arc lamps the convenient arrangement of the parts manipulated in trimming the lamp will prove of interest. The inner globe is large and surrounds the lower carbon holder. The gas check is fastened to the frame and the inner globe is forced up against it by a small Stub's steel rod curving around beneath the globe and looped into an eye at its end to surround the tip of the globe and hold it firmly. The rod is pulled up by a coiled spring surrounding its upper end. The top of the enclosing globe is ground true and the force with which it is held up against the gas check gives a much tighter enclosure than does any bottle cap resting loosely on the top of a globe. The globe also partakes of the advantages of all those which are outside of instead of inside the lower carbon holder, in that the increased size gives a greater area for the spread of the carbon vapors and consequently it becomes dirty more slowly. In addition, it is less liable to breakage by the burning of the arc too near the bottom or top of the globe. The lower carbon holder is supported by two small rods or wires only about ⅛ inch in diameter, thus avoiding noticeable shadows, the rod supporting the inner globe being located in the shadow of one of the inner rods.

The regulating mechanism of the lamp also contains points of interest. The magnet is not of the concentric form, but consists of two coils wound on vulcabeston spools. Each of the vulcabeston heads of each of these spools is formed with a lug or ear which is fastened by one screw directly to the cast-iron frame of the lamp. By disconnecting the wires and unscrewing these two screws either coil can be removed and replaced without taking down any more of the lamp than the shell.

The lamp is interchangeable between a.c. and d.c. circuits with the following slight changes: The substitution of a resistance coil in place of the reactive coil, of a solid armature in place of the laminated one, and the removal of the keeper closing the upper end of the magnetic circuit. On the a.c. lamp the keeper so improves the pull, which is naturally weak with alternating currents, that the same winding is used for both styles of current. The armature in the a.c. lamp is fastened to the rest of the clutch mechanism through a spring, which takes out the vibration and prevents humming. The current is carried from the magnet to the upper carbon through a flexible asbestos-covered cable which passes through a slot in the carbon holder tube or guide and is attached directly to the holder clamping the upper end of the carbon. Thus no sliding contacts are used.

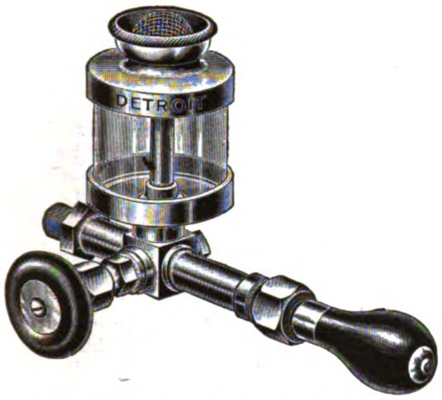


FIG. 5.—OIL PUMP WITH GLASS BODY.

The clutch is one of the best points of the lamp. Its construction is shown by a glance at Fig. 6 more clearly than by any description. It consists of three knuckle joints equally spaced from each other around the carbon, forming a sort of triangular toggle. It holds the carbon in accurate alignment with great firmness when drawn up. When tripped by the small table which carries the three toggles resting upon the gas check, a sneak feed is obtained. Owing to the fact that the gas check is fastened to the frame and in its position is independent of the length of the inner globe, the tripping point is always uniform and independent of the globe length.

To show the care taken with the details of this lamp, the following minor points may be mentioned: The connections of the two coils of the regulating magnet to each other and to the wires leading to and from them are made by means of sleeve connectors, which are surrounded by asbestos sleeves tied on with asbestos cord. The dash pot, which, like other parts of the mechanism, is made of a heavy brass casting, is pivoted to the frame to give flexibility and prevent binding, and alignment with the piston is maintained by making the latter very long. The piston has several grooves around its surface to serve as air-packing rings. The dash pot is provided with a check valve in the piston to allow the carbon to fall quickly when the magnet weakens. The cable of the upper carbon is fastened at its middle point to prevent it from catching or kinking, and its ends are clamped and separately fastened to the terminals to remove all strain from the ends of the cable strands themselves.

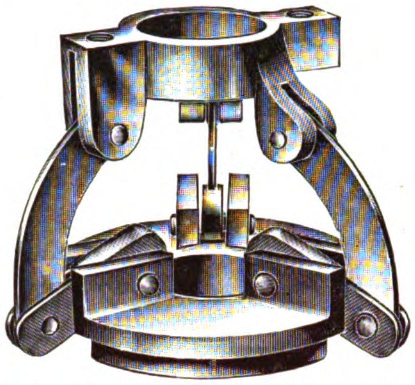


FIG. 6.—THE CLUTCH OF THE IMPERIAL LAMP.

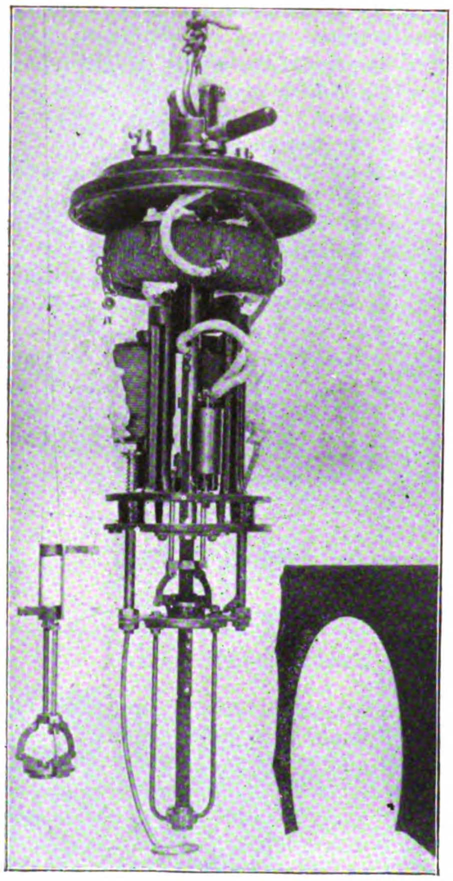


FIG. 7.—THE IMPERIAL ARC LAMP SHOWING TO THE RIGHT AN INNER GLOBE, AND TO THE LEFT THE CASTING FOR THE STRAIGHT-LINE MOVEMENT BETWEEN MAGNET, DASH-POT AND CLUTCH.

The design of the lamp contains many other details for the purpose of eliminating trouble and making the lamp convenient to trim, adjust or repair.

INTERCHANGEABLE OIL PUMPS.

The accompanying illustrations, Figs. 5 and 8, show the new style oil pumps that have recently been put upon the market by the Detroit Lubricator Company of Detroit, Mich. An advantage claimed for them over the ordinary styles is that the body can be easily removed from the frame, should it be desirable to do so for the purpose of removing any dirt or sediment deposited by the oil, without removing the oil pump proper from the steam pipe. Each style is made with both vertical and horizontal connecting shanks, and the bodies of the whole four styles, of the same sizes, are interchangeable. For instance, the body of the brass oil pump with vertical connecting shank can be interchanged with the glass body of the pump shown with horizontal shank, etc. Each style is also equipped with strainer filler. The manufacturers have issued a pamphlet showing these oil pumps, also their new style glass and brass oilers, and will send same to any address on application.

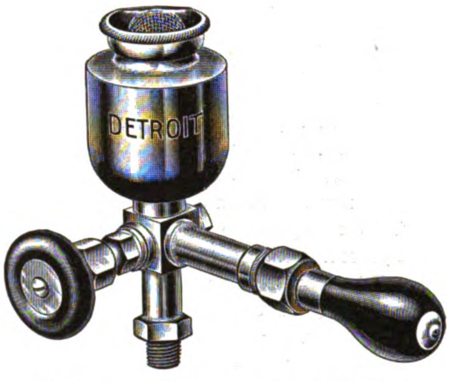


FIG. 8.—OIL PUMP WITH BRASS BODY.

A SET OF PACKING TOOLS.

The modern engineer fully realizes the importance and true saving feature of good tools around the engine room. Not the least in the list of engine-room tools is a set of packing tools. The cut shown in Fig. illustrates a special set of packing tools made from tool steel and warranted not to break or bend in removing packing from stuffing boxes of engines, pumps, etc. These tools are made in various sizes and are handsomely nickel plated. These tools are manufactured by the Mound Tool & Scraper Company, St.

Louis, Mo., who also manufacture a full line of scraping tools and other specialties for engineers' use.

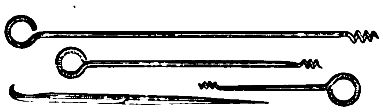


FIG. 9.—A SET OF PACKING TOOLS.

A NEW PARTY-LINE TELEPHONE SYSTEM.

The Holtzer-Cabot Electric Company of Boston, Mass., is placing on the market a new bridging-bell party-line telephone system using a transformer to step up from a low-resistance bell and magneto to the line. Fig. 10 shows two stations, in which, for the sake of clearness, the signaling system alone is shown. At each station a specially designed transformer is mounted in the magneto box. This transformer, shown in Fig. 11, is provided with two windings in the usual manner, the high-resistance winding being connected to the main circuit and the low-resistance winding to the local circuit, the latter including in multiple a low-resistance ringer and magneto generator.

When the generator is operated the ringer current divides, part going through the striker, R, and the remainder through the winding, S. The voltage of the latter portion is stepped up in the high-potential winding, resulting in a current of sufficient e.m.f. to operate the ringers throughout the system. When the calling current from this transformer reaches the other stations, it goes through the high-resistance winding, thereby generating in the low-resistance winding a current suitable for the 80-ohm ringer, R, in the local circuit.

The transformer windings are, of course, reversible in inductive effect, the windings, P and S, being alternately primary and secondary, depending on whether a call is being sent or received. The generator, G, is provided with an automatic cut-in switch or push button, as may be desired. The ringer, R, may be placed in series with the transformer secondary and generator, and in some cases this connection is desirable.

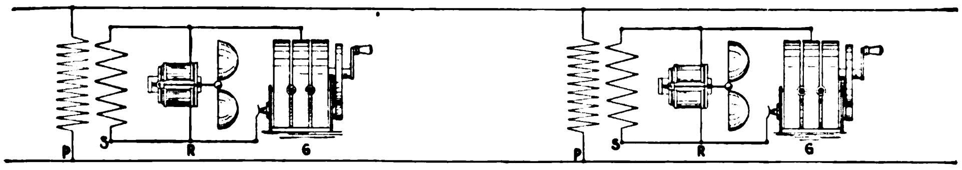


FIG. 10.—DIAGRAM OF CIRCUIT OF TRANSFORMER BRIDGING-BELL SYSTEM.

Among the advantages of this system is that it permits the ringer to be wound with a much coarser wire, and hence with more copper and less insulation. The same remark applies to the design of the magneto. It is impossible to raise the voltage of the ordinary magneto telephone generator beyond certain limits in the machine itself without making the permanent field so large as to result in a machine excessively large and clumsy; and on the other hand, if the speed of the armature is increased beyond a certain value in order to increase the voltage, the bell hammer will not follow the alternations. By the use of the transformer the most efficient type of magneto may be designed and the voltage stepped up to any desired value.

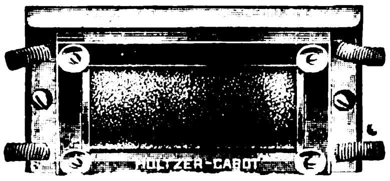


FIG. 11.—TRANSFORMER FOR BRIDGING-BELL SYSTEM.

NEW BOOKS.

The Manufacture of Carbons for Electric Lighting and Other Purposes. By Francis Jehl. New York: D. Van Nostrand Company. 230 pages, illustrated. Price, $4.00.

While most branches of electrical work and allied industries abound in books and pamphlets, some of the chemical processes —either themselves electrical in character or producing supplies used in electrical work—are more or less secret arts, the manufacturers doing everything in their power to prevent the spread of the special knowledge which they have derived by experimentation in their own work. This is true of the manufacture of carbons. On this account the work by Mr. Jehl will be particularly welcome to all interested in carbon manufacture, but unable to obtain desired information owing to the reason given above. Mr. Jehl was an assistant to Mr. T. A. Edison in his early work at Menlo Park, N. J., and has since been engaged with a German carbon firm, so that his knowledge is based on practical experience. Regarding the question much agitated in this country a year or two ago, when the high carbon duty was imposed, as to whether high-grade carbons for arc lights could not be made in this country, Mr. Jehl states that "The whole object of this work is to show that high-grade carbons can be made and manufactured in every country, and to dispel the idea that the art is confined solely to two or three countries of Europe." He also states that "It has been the object of the author to give a concise account of the art of making high-grade carbon, and he would here mention that the secret of manufacturing high-grade goods lies more in the process of carbonization—i. e., the furnace used—than in anything else." The book contains a description of the gas generators necessary for the production of low-cost gas for use in carbonizing furnaces. It also contains instructions for the building of a carbon factory, plans drawn to scale showing the arrangement of a model factory, and an estimate of the capital expenditure. The contents of the book have appeared in part in serial form in the pages of the London "Electrician."

LEGAL NOTES.

THE PHOENIX BATTERY MANUFACTURING COMPANY, St. Louis, Mo., made an assignment on December 28, 1899, to John A. Gilliam, assignee. The demands of creditors will be adjusted by the assignee at his office in the Security Building, St. Louis, Mo., on the 19th, 20th, and 21st of February.

PERSONALS.

MR. J. M. DUNCAN, Manufacturers' Agent for all the apparatus needed in complete power plants, has removed his office to 39 Cortlandt Street, New York City.

MR. J. C. JONES, of the Harrison Safety Boiler Works, Philadelphia, was recently confined to him home for a month by serious sickness, but was reported about the middle of January to be rapidly recovering, and expecting to be at his office again in the near future.

MR. H. C. CUSHING, JR., well known to electrical engineers as the author of "Standard Wiring," has opened an office at 39 Cortlandt Street, New York City, where he will practice consulting engineering in connection with insurance brokerage, making a specialty of manufacturing and electrical risks. This rather unusual combination of two professions generally considered quite apart from each other, will, it is hoped, be of advantage both to the insurance companies and the insured; the former through the agent's knowledge of safe and dangerous conditions, and the latter owing to his ability to suggest changes which will bring installations more nearly in accordance with insurance regulations, and which will, in consequence, lower the rate. Mr. Cushing has served as Chief Electrician of the Boston Board of Fire Underwriters and the Fire Underwriters' Tariff Association of New York, and has more recently been connected with one of the most prominent insurance brokerage houses in New York City.

TRADE PUBLICATIONS.

THE ASHTON VALVE COMPANY, Boston, Mass., has had printed a card of testimonials of the Barclay patent lubricators with single and double connections.

THE PHILLIPS INSULATED WIRE COMPANY, Pawtucket, R. I., has prepared a calendar to remind its friends and patrons of the weatherproof "O. K." line and house wires.

THE CHASE-SHAWMUT COMPANY, Boston, Mass., issues from its switchboard department bulletin No. 8 on isolated-plant switchboards, arc-light switchboards, tablet boards and Cushing theater switchboards.

MESSRS. MACHADO & ROLLER, New York City, are sending to their friends and patrons a very neat calendar giving points on the advantages of Whitney instruments of which they are the New York agents.

THE ELECTRIC APPLIANCE COMPANY, Chicago, has recently issued sheets 595 to 598 of its file catalogue, setting forth the merits of new departures in the lines of arc-lamp fixtures, lightning arresters, soldering irons, etc.

American Electrician.

Vol. XII. New York, March, 1900. No. 3.

THE NEW WATER POWER OF THE HARTFORD ELECTRIC LIGHT COMPANY.

BY PROF. W. L. ROBB.[*]

During the past year the Hartford Electric Light Company has added to its water power by developing a second power on the Farmington River. This power is situated eleven miles from the central station in Hartford; approximately the same distance from Hartford as the power previously developed, but three miles further up the river.

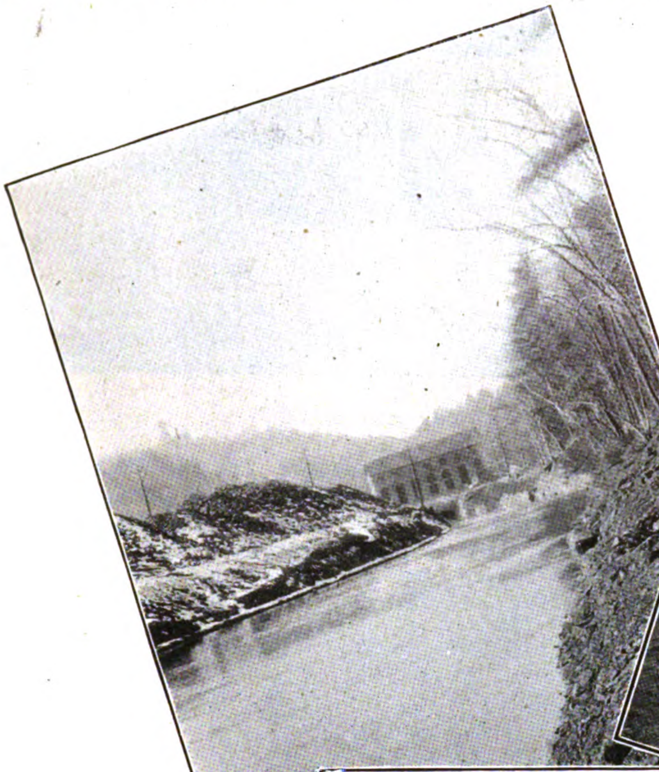


FIG. 1. — THE TAIL-RACE FORMED BY DEEPENING A BRANCH CHANNEL OF THE RIVER AROUND AN ISLAND.

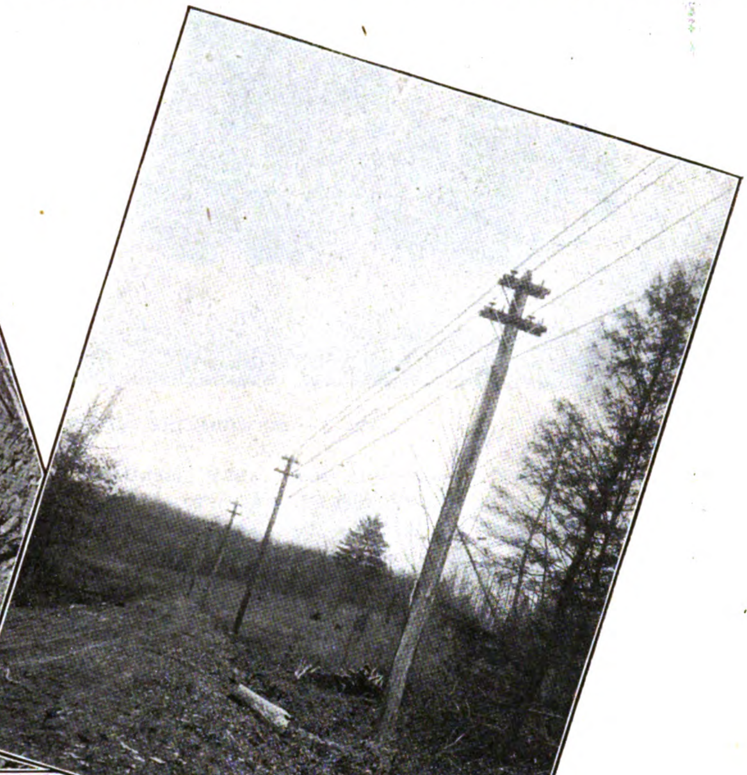


FIG. 2.—A VIEW ON THE POLE LINE, SHOWING THE ARRANGEMENT OF CROSS-ARMS AND WIRES.

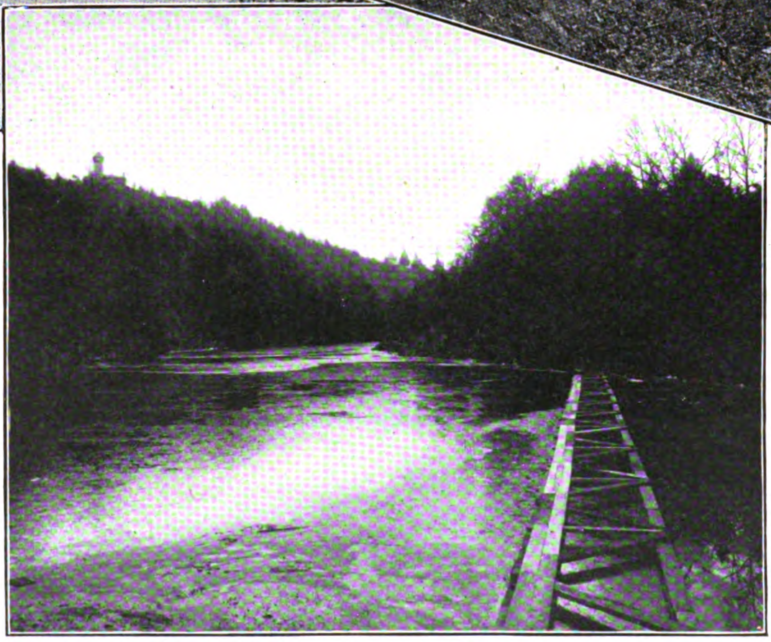


FIG. 3.—THE BOOM ABOVE THE DAM FOR KEEPING ICE AND DRIFTWOOD FROM THE FEEDER TUBES.

The location for the new dam is ideal. The banks and bed of the river at this point are of trap rock, practically free from seams; the river is vary narrow and the banks are almost vertical The fall in the river which could be obtained at this point is 25 ft. About two hundred feet below the site of the dam the river is divided into two channels by an island about one thousand feet long. The fall in the river to and alongside this island is about six feet. There is no satisfactory site for a dam at the lower end of the island, as the river at this point is comparatively wide, the banks are low, and the bed of the river would not furnish satisfactory foundation. As it was desirable to obtain the six additional feet of fall the inlet into the narrow channel was closed and the channel deepened

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[*] Consulting Electrical Engineer of the Hartford Electric Light Company and Resident Engineer in Charge of the work described herein.

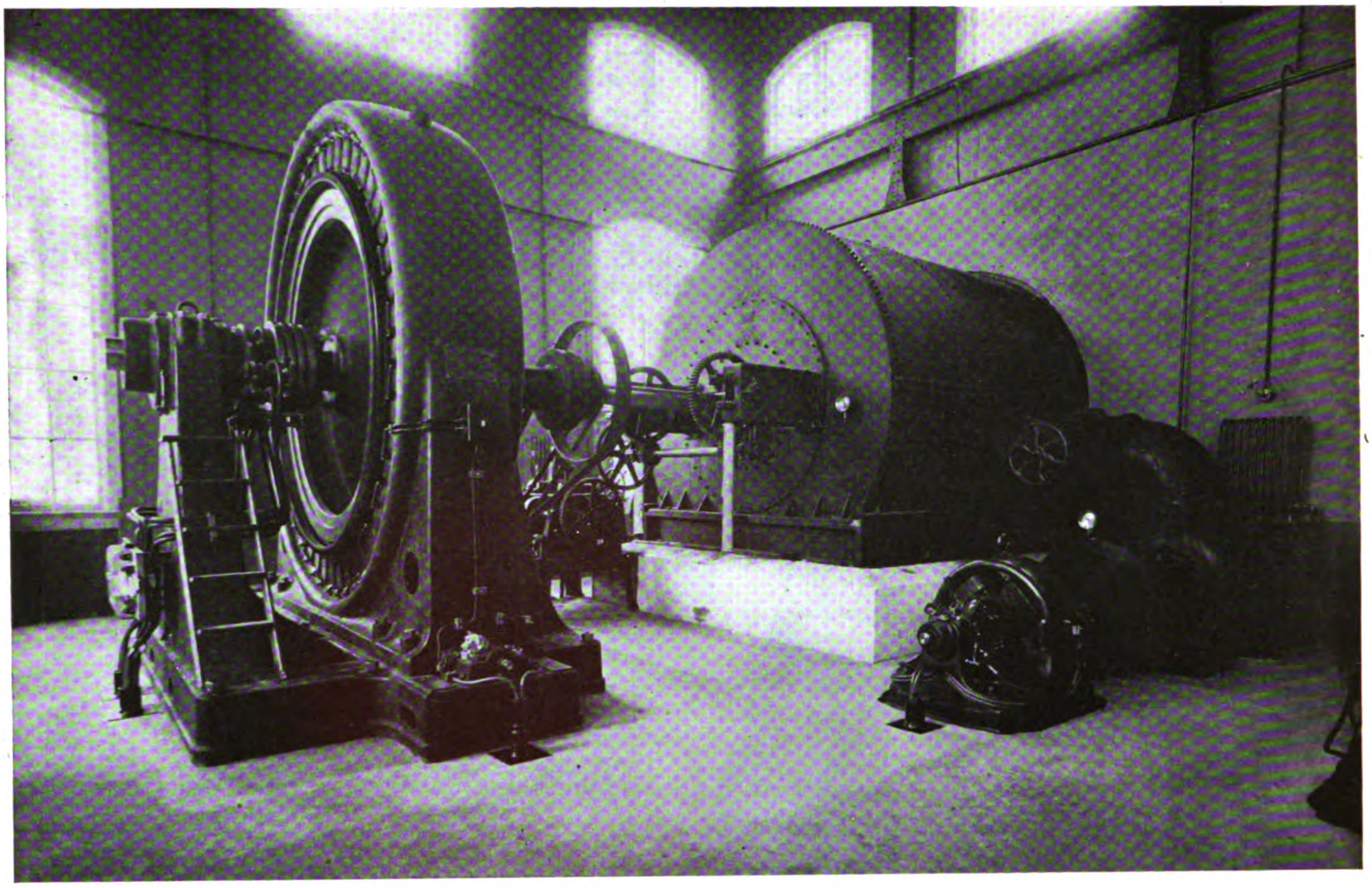
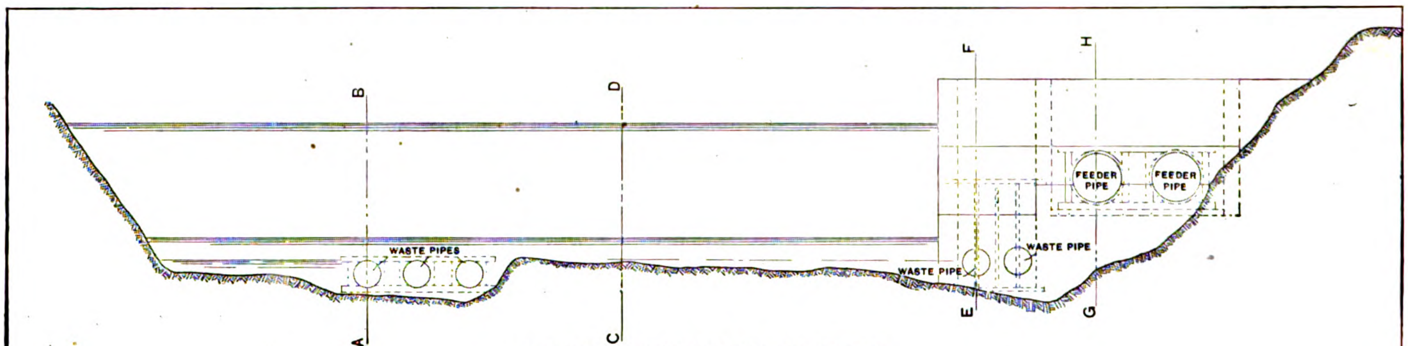


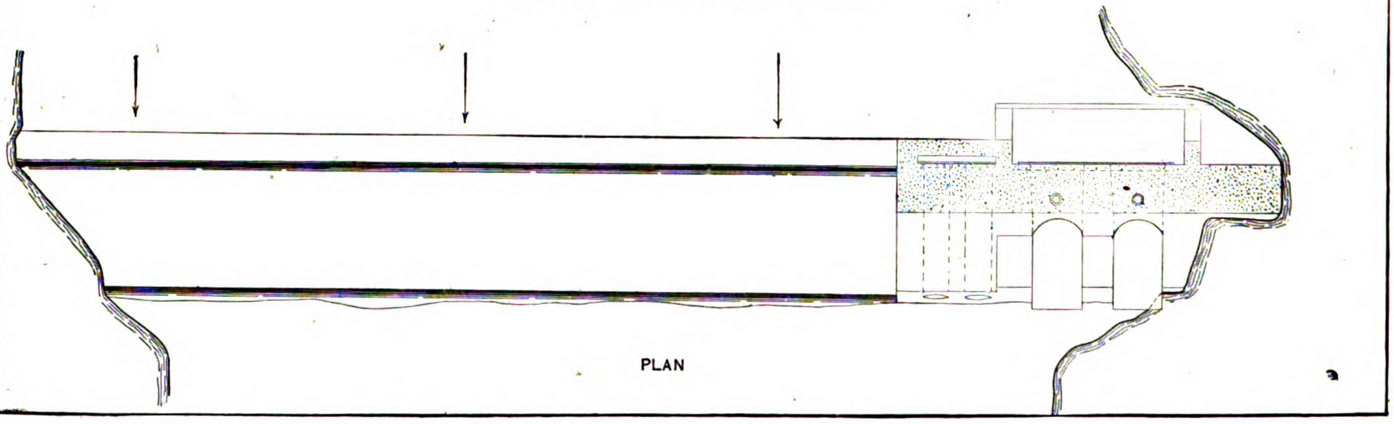
FIG. 4—ONE COMPLETE SET OF WHEELS, GENERATOR AND EXCITER

to make a satisfactory tail-race, and thus to make it possible to use the six feet additional fall. The power house was located at the head of the tail race, about two hundred feet below the dam, it being found preferable to improve the channel above mentioned for a tail race rather than to extend the feeder pipes and locate the power house further down stream.

The dam was built of concrete, as there was no stone to be obtained in the immediate neighborhood for the construction of a stone dam. The trap rock taken from the wheelpit and from the upper end of the tail race proved just sufficient for the stone in the concrete. There was the further advantage in favor of the concrete dam that it could be constructed in very



ELEVATION OF DAM LOOKING UP STREAM



PLAN

FIG. 5.—PLAN AND ELEVATION OF DAM, SHOWING LOCATION OF TEMPORARY WASTE PIPES FOR CARRYING FLOW OF RIVER DURING CONSTRUCTION.

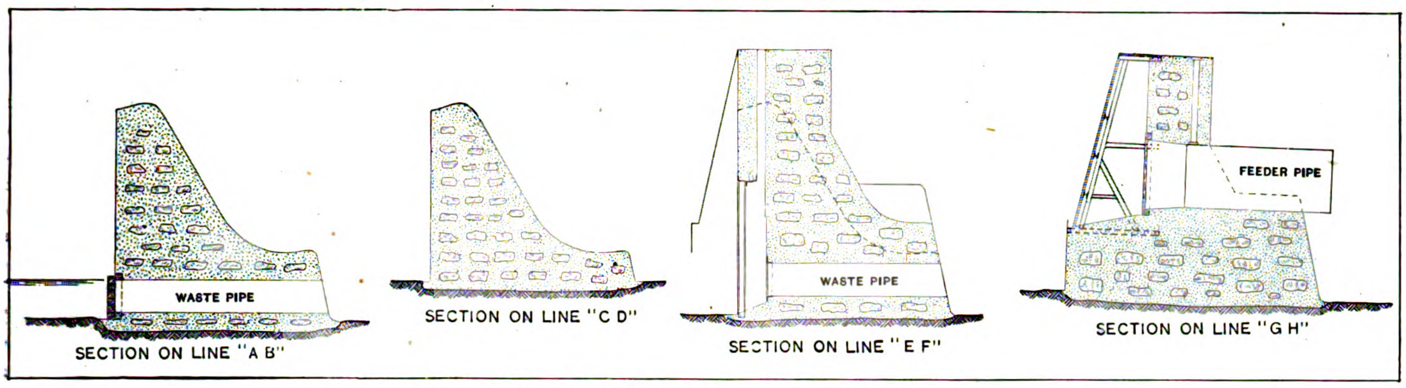


FIG. 6.—SECTIONS OF DAM ON LINES SHOWN IN FIG. 5.

much shorter time than could a stone one. All the work, including dam, power house, machinery and transmission line, was completed within seven months after letting of contract. Sections of the dam are shown above in Fig. 6. The crest of the dam is about 180 ft. long, while the waste-gate abutment, forebay and end abutment are about 80 ft. long. The thickness of the dam at the base is about 32 ft., and at the crest 6 ft. The height of dam is about 25 ft. above surface of water.

In preparing the foundation for the dam the water in the river was diverted by cofferdam and crib, and the water was pumped out until rock was exposed. Loose gravel and rock were removed, and the old surface of the rock was taken off by squib blasts, so that the cement concrete could have a clean, sharp surface to which to adhere. All the surfaces of the rock were made to slope upstream. At the ends of the dam and abutment loose rock was removed and squib blasts were put in to remove the old surface.

The section on line, A B, shows the contour through the deepest part of the river. The cofferdam was built around this portion, and three waste pipes 5 ft. in diameter were built in this portion of the dam as shown in the sectional drawing. These three waste pipes were capable of carrying the normal flow of the river during the further construction of the dam. On the upstream end of these waste pipes a timber frame was built in the dam, and when the dam was completed and ready to be filled they were permanently sealed with 12-in. by 12-in. Southern pine timber.

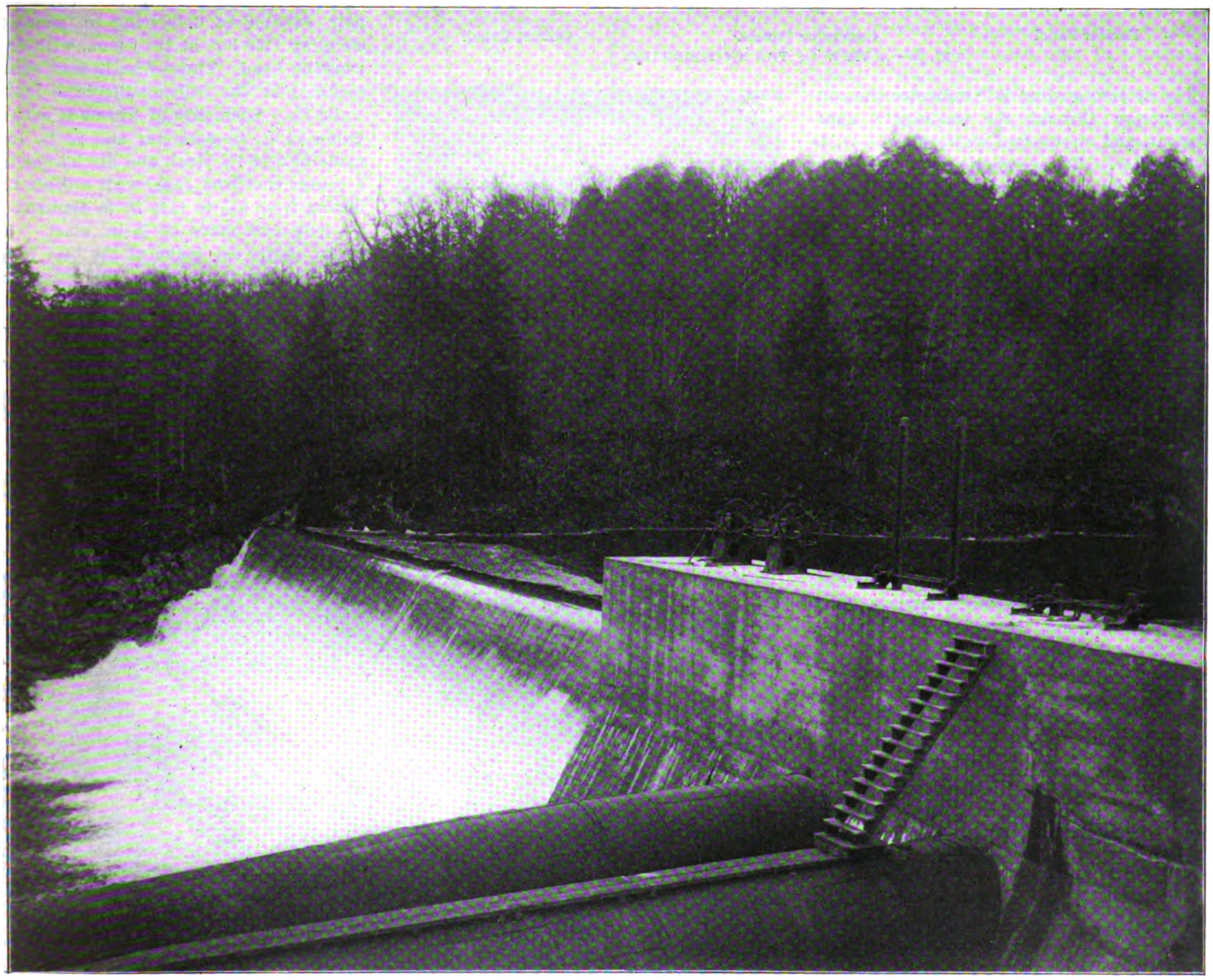
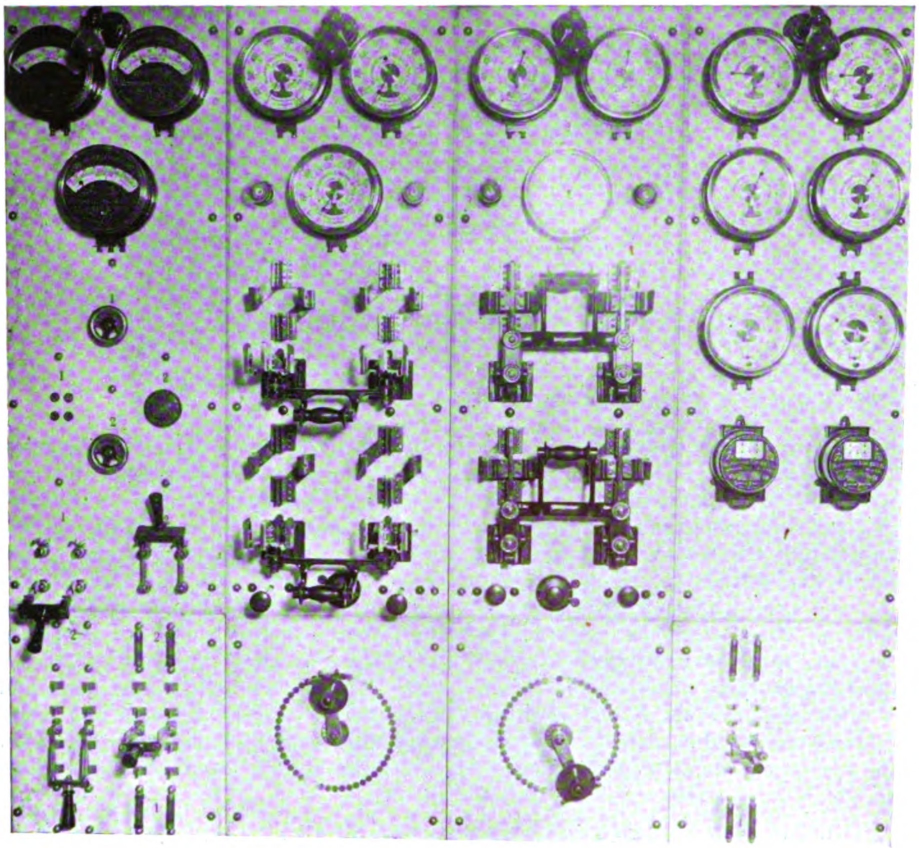


FIG. 7.—VIEW OF DAM FROM FOREBAY END.



Exciter Panel. Generator Panels. Output Panel.

FIG. 8.—A VIEW OF THE SWITCHBOARD.

The section on line E F indicates the construction through the waste-gate abutment, and shows two waste pipes 5 ft. in diameter. These waste pipes are controlled by gates, and were built in the dam so that the electric light company could control the level of the water on the dam, except in flood time. It was considered advisable to do this so that the electric light company could build the dam to the extreme height of the flowage rights which it controlled. In case the load is light the waste gates can be opened to prevent the water setting back on the next water power. Section on line G H is taken through a feeder pipe. The feeder pipes are 9½ ft. in diameter and about 200 ft. long.

The dam, forebay and abutments are built of concrete. First, a bed of concrete, 12 ins. deep was made; then blocks of stone were placed in the soft concrete with the smallest surface down. These stones were not allowed to come within 12 ins. of each other. Concrete for the body of the dam and abutments, where random block stone was allowed to be used, was composed of one part Portland cement, having a tensile strength of 500 pounds to the square inch, of three parts clean, sharp sand, and three parts broken stone that screened 2 ins. The block stone used was taken from the trap-rock excavation for the wheelpit and consequently had clean sharp surfaces. Twelve inches of the outside of the dam and all the outside surface were built of concrete composed of one part Portland cement, three parts of clean sharp sand and two parts of broken stone that screened ½ in. The completed dam and abutments and a portion of two of the feeder tubes are shown in Fig. 7. The view of the river above the dam, showing the boom for keeping the ice and driftwood away from the feeder tubes is shown in Fig. 3. This boom is constructed in the form of a truss out of 12-in. by 12-in. timber, braced with 3-in. planking. The tail race, which was constructed by deepening the narrow channel of the river about 4 ft., is shown in Fig. 6.

The power house is 42 ft. wide by 84 ft. long, and 29 ft. from the floor to the lowest chord of the roof trusses. The bottom of the tail race under the power station is excavated 24 ft. below the floor, and the water in the tail race stands 15 ft. below the floor of the station.

The floor of the station and the machinery, including generators and wheels, are carried on concrete arches built in the tail race. The concrete used in these arches is composed of one part Portland cement, three parts of sand and four parts of broken stone which screened 2 ins. The exterior of the power house, with lightning arrester and oil-house, are shown in Fig. 10.

EQUIPMENT OF POWER HOUSE.

Power is developed by means of two pairs of horizontal turbine wheels, each pair capable of delivering to generator coupling 1150 h.p. at 164 r.p.m., with 29 ft. working head. These wheels were manufactured by the Stilwell-Bierce & Smith-Vaile Co. Each pair of wheels is set in a flume 12 ft. in diameter and 23 ft. long, made of 5/16-in. steel, and discharges into a center cast-iron case, with a draft tube flaring from 8½ to 11½ ft. in diameter, 23 ft. long and made of ⅛-in. steel. The wheel shafts are made of the best forged steel 7⅜ ins. in diameter, and direct-connected by standard face coupling to the shaft of generators. There are two

FIG. 9.—JOINT IN ALUMINUM LINE.

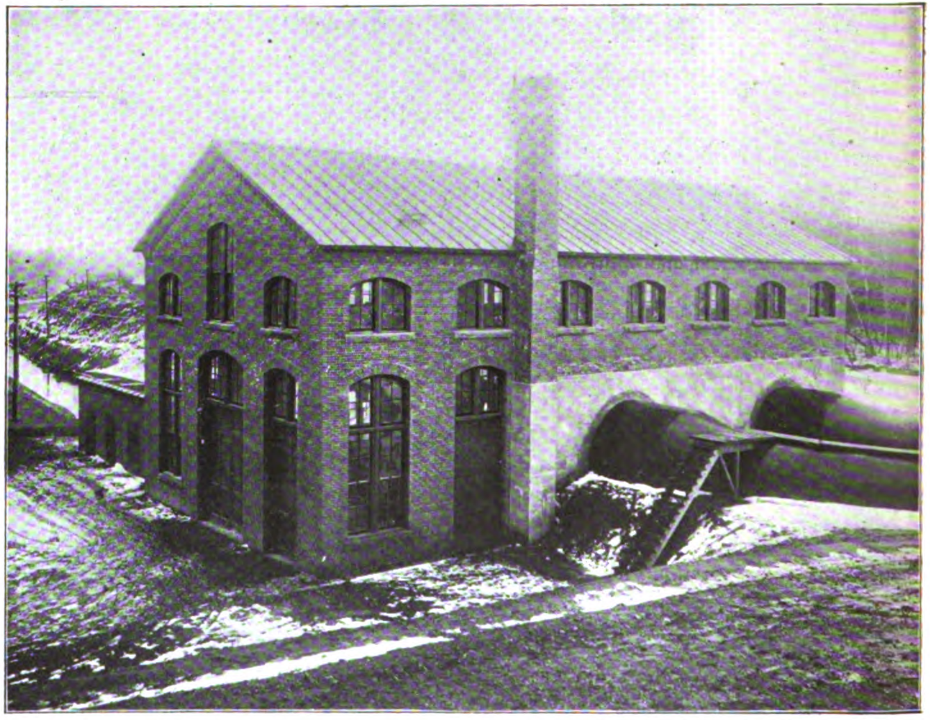


FIG. 10.—VIEW OF POWER HOUSE FROM UP-STREAM SIDE.

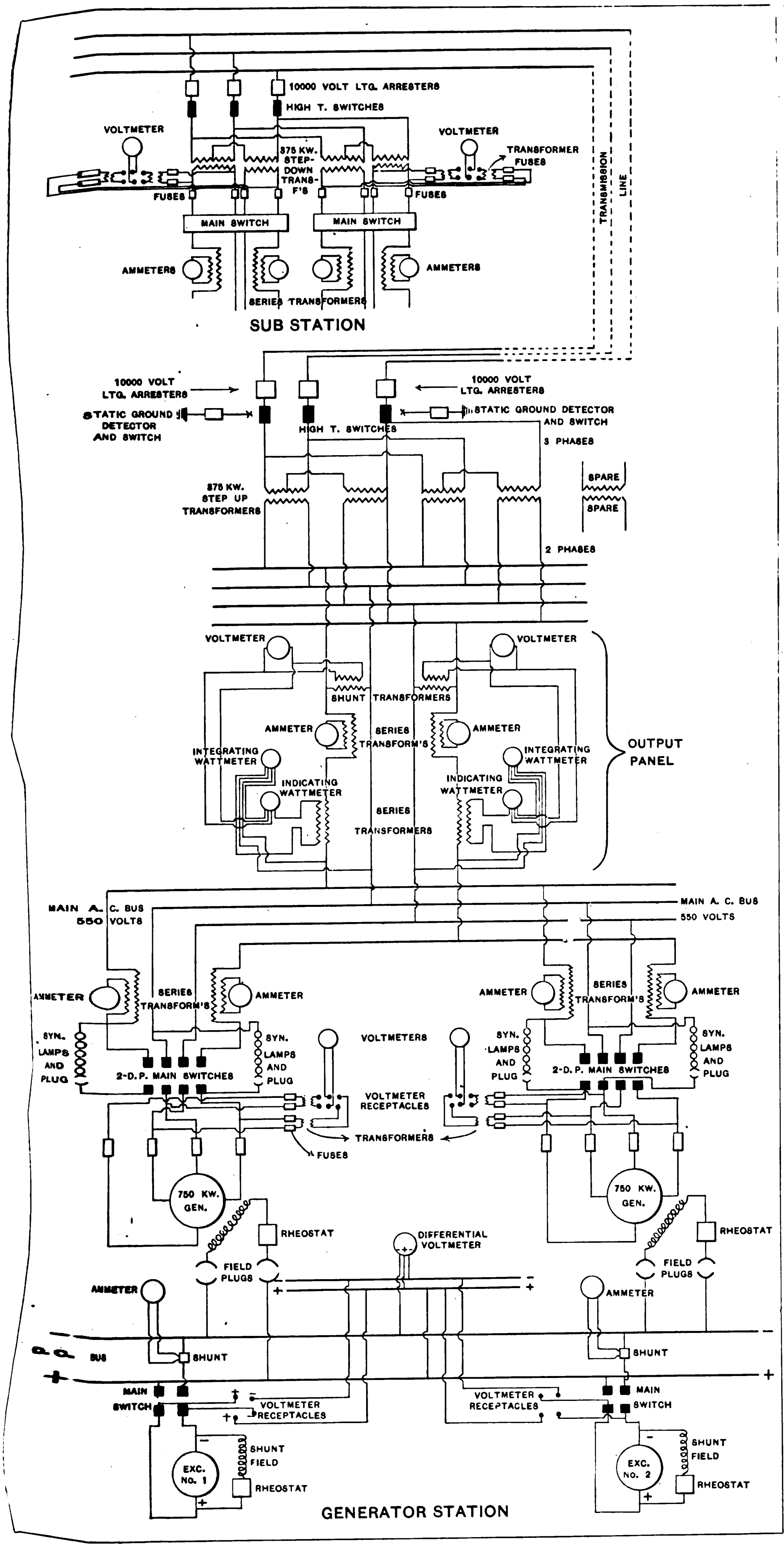

10000 VOLT LTG. ARRESTERS
HIGH T. SWITCHES
VOLTMETER
375 KW. STEP-DOWN TRANS-F'S
VOLTMETER
TRANSFORMER FUSES
FUSES
FUSES
MAIN SWITCH
MAIN SWITCH
TRANSMISSION LINE
AMMETERS
SERIES TRANSFORMERS
AMMETERS
SUB STATION
10000 VOLT LTG. ARRESTERS
10000 VOLT LTG. ARRESTERS
STATIC GROUND DETECTOR AND SWITCH
HIGH T. SWITCHES
STATIC GROUND DETECTOR AND SWITCH
3 PHASES
SPARE
SPARE
375 KW. STEP UP TRANSFORMERS
2 PHASES
VOLTMETER
VOLTMETER
SHUNT TRANSFORMERS
AMMETER
SERIES TRANSFORM'S
AMMETER
INTEGRATING WATTMETER
INTEGRATING WATTMETER
OUTPUT PANEL
INDICATING WATTMETER
INDICATING WATTMETER
SERIES TRANSFORMERS
MAIN A. C. BUS 550 VOLTS
MAIN A. C. BUS 550 VOLTS
AMMETER
SERIES TRANSFORM'S
AMMETER
AMMETER
SERIES TRANSFORM'S
AMMETER
SYN. LAMPS AND PLUG
SYN. LAMPS AND PLUG
VOLTMETERS
SYN. LAMPS AND PLUG
SYN. LAMPS AND PLUG
2-D.P. MAIN SWITCHES
2-D.P. MAIN SWITCHES
VOLTMETER RECEPTACLES
TRANSFORMERS
FUSES
750 KW. GEN.
750 KW. GEN.
RHEOSTAT
DIFFERENTIAL VOLTMETER
RHEOSTAT
FIELD PLUGS
FIELD PLUGS
AMMETER
AMMETER
D.C. BUS
SHUNT
SHUNT
MAIN SWITCH
VOLTMETER RECEPTACLES
VOLTMETER RECEPTACLES
MAIN SWITCH
SHUNT FIELD
EXC. NO. 1
RHEOSTAT
SHUNT FIELD
EXC. NO. 2
RHEOSTAT
GENERATOR STATION

FIG 11.—DIAGRAM OF CIRCUITS OF GENERATING AND SUB-STATIONS.

wheels for exciters, each set in a cast-iron case, and capable of delivering to each exciter 45 h.p. at 550 r.p.m., under 29 ft. working head. The draft tube of each exciter wheel is connected to the draft tube of the generator wheel, and the exciter feeders are tapped out of the sides of the flumes of the main wheels. Each pair of generator wheels is direct-connected to a 750-kw. generator, and each exciter wheel is connected to a 30-kw. generator. Fig. 4 shows one of the two generating sets complete with exciter set.

The station is equipped with a motor-driven air compressor having a capacity for compressing 5 cu. ft. of free air per minute against 150 lbs. pressure to the square inch. The compressor is connected with the necessary piping and valves to the generators and switchboard, and the air thus compressed is used for cleaning the apparatus.

The station is equipped with a 15-ton traveling crane, and the water-wheel casings are brought into the power house so that the crane can be used in handling all machinery.

The generators were manufactured by the Westinghouse Electric & Manufacturing Company, and generate two-phase alternating current under a pressure of 500 volts. The current passes to raising transformers and is changed over to a three-phase current under a pressure of 12,000 volts, at which it is transmitted to the central station at Hartford. At Hartford the pressure is lowered to 2400 volts, and feeds into the busbars in parallel with the current from the other water power station, and the local steam station. Electrically, the two water power stations are situated 22 miles apart.

A diagram of the connections of switchboard is shown in Fig. 11, and Fig. 8 is an illustration of the switchboard at the power station. The switchboard consists of four panels. The first contains ammeters and voltmeter for the exciters, the second the necessary switches for both phases of one of the generators. The third panel is similar to the second. The fourth panel is a load panel, and contains ammeter, voltmeter, indicating wattmeter and recording wattmeter for each phase.

One of the most interesting features of this particular transmission is the line. The current is transmitted from Farmington to Hartford over aluminum wire, this being the first case in the East where this wire has been used. The wire used is equivalent in conductivity to No. 0000 copper. The line was built of aluminum primarily because it could be purchased at 20 per cent. less than copper having the same conductivity. The wire used is made of seven strands. Until the wire reaches the underground district in Hartford, it passes along a private right-of-way; the first half mile over property of the electric light company, and the remaining distance along the tracks of the Central New England Railroad. The wire used is not insulated, the insulation relied on being the porcelain insulators on which the line is supported. The porcelain insulators are double petticoated and are about 6 ins. in diameter at the base. The wire was furnished in lengths of about 2000 ft. The joints were made in the following manner: the ends of the wire were first cleaned with hydro-fluoric acid, and then tinned over. The strands of the wire were somewhat spread apart and placed end to end in a brass casting, the inside of which was somewhat oval. The casting was then filled with block tin. A test of several of these joints was made in a testing machine, and their tensile strength proved to be greater than that of the line itself. Figs. 2 and 9 show the general construction of the line, and one of the joints in the aluminum wire.

The total cost of this development, inclusive of water rights and transmission line, was $125 per horse power. The specifications and drawings for the dam and hydraulic machinery were furnished by Mr. A. C. Rice, of Worcester, Mass., who acted as consulting hydraulic engineer to this work.

The Central Power Station of the Metropolitan Street Railway Company of New York City.

As all the traction engineering world knows, the New York Metropolitan Company was a leader in the adoption of the open conduit method of supplying cars with electric power. Prevented by public feeling on the subject from putting in overhead trolleys, the company was forced to maintain horse and cable traction until some unobjectionable form of trolley could be devised. Finally the company, in conjunction with the General Electric Company, determined to solve for its own use the problems of the open conduit. An experimental line was established some three years ago in Harlem and after a period of successful operation plans were made to convert the whole trackage of the company throughout Manhattan Island, aggregating some 225 miles, into open-conduit roads.

Starting in to build an electric system with an enormous traffic already developed, the company was not hampered in its power station plans by the possession of small power stations already built and could lay out its designs for the generation of electric power without being forced to consider the utilization of old apparatus. The design and erection of a power station with units of the size desirable for such a large load were found, however, to require so many years' time that three temporary power stations with an aggregate capacity of about 10,000 h.p. were equipped, simply to run the cars while the main station was under erection. These temporary stations, in spite of the fact that they would only be utilized for two years and would not be maintained after that even as a reserve, were equipped with the best of General Electric 850-kw. machines direct coupled to cross-compound Corliss engines. The main station has now reached such a stage that it lifts a large portion of the load during the greater part of the day from the temporary stations. A brief outline of the general scheme of the system may be of interest before the details are enlarged upon.

The central generating plant is located on the water front and covers a whole city square bounded by 95th and 96th Streets, First Avenue and the East River. It will contain, when completed, eleven vertical cross-compound engines rated at 4,500 h.p. each, and capable of giving 6,000 h.p., each engine being direct coupled to a 3,500-kw. three-phase alternator. These alternators deliver the high pressure of 6,600 volts direct from their windings and the power at this pressure is transmitted to sub-stations in which it is stepped down and passed through rotary converters which deliver direct current suitable for delivery to the car motors. The power station will have, when completed, a maximum capacity greater than that of any other electrical plant and for that matter any single steam plant in the world over, although this distinction will probably not remain with it very long as other larger plants are already under way in New York City.

At present three generating units are completed and two more are under erection in the station, the other six being still in the shops. Part of the space to be filled by the final six engines is now occupied by one of the three temporary power plants mentioned above. This temporary plant contains two 850-kw. direct-coupled sets and has been running in its wooden structure while the large engine room of the permanent plant was erected around and over it.

The chief features of the new power station are briefly as follows:

There is no mechanical draft apparatus and there are no economizers. All auxiliaries are driven by steam engines and their exhaust is used in secondary feed-water heaters, primary heaters taking the exhaust steam between the main engines and their condensers. There are three floors of boiler rooms, the upper one being surmounted by coal bunkers.

The building is of the steel skeleton type with unusually elaborate architectural treatment, as the exterior view, Fig. 1, indicates. The four walls contain lofty arched windows, which give an unusual amount of light to the interior. The main engine room floor is well above the street level as the section, Fig. 2, shows, and covers a basement containing all the engine-room steam piping, separators, condensers, primary heaters, air pumps, etc. Below this basement is a sub-basement containing circulating water pipes, electrical conduits and other connections. The boiler rooms have central passages running the length of the building with boilers facing them on either side. The two rows of boilers are interrupted in the center of the building by the chimney, dividing each level into two distinct rooms as the plan, Fig. 3, indicates.

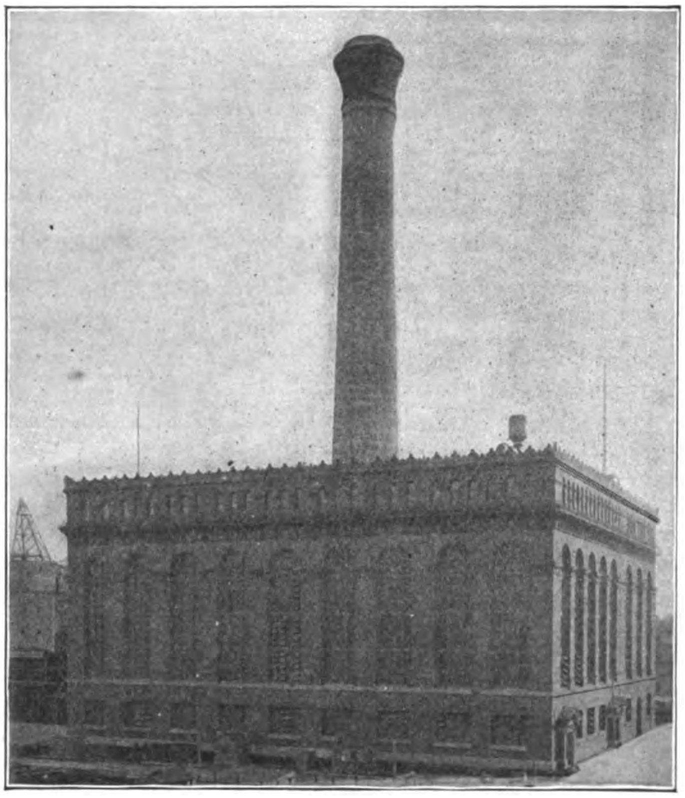


FIG. 1.—VIEW OF THE POWER HOUSE. COAL-HANDLING TOWER APPEARS ON EXTREME LEFT.

THE COAL-HANDLING APPARATUS.

Coal is received from canal boats or barges which can dock immediately in front of the building. It is hoisted from their holds by a bucket having a capacity of one and one-half tons, suspended from a jib—crane projecting from a steel tower on the edge of the wharf. The coal thence passes through a receiving hopper and crushing machine into Mead coal conveyors, which carry it up and over the bunkers. The coal-conveying apparatus is in duplicate, i. e., there are two separate conveyors side by side, passing from the tower into the station. These conveyors do not run down to the basement at the inshore end of the power station and collect ashes on the way back to the water front, but double back above the bunkers. The ashes will be handled from the ash chutes in the boiler-room basement by means of separate conveyors or an ash tramway. No definite decision as to which will be used has as yet been made. The coal bins above the boiler room are two in number, separated by the chimney, each having a capacity of nearly 5,000 tons, giving a total storage capacity of about 10,000 tons. As the section and elevation of the station shows, the floors of these bins are of a flat W shape, the two downward points of the W discharging into the chutes which carry the coal directly into the hoppers of the mechanical stokers in the three boiler levels below the bins. The walls of the coal bunkers are made up of concrete formed between eye beams and covering the eye beams on the inside of the bin so that in case of fire in the coal the steel work will not become heated sufficiently to give way.

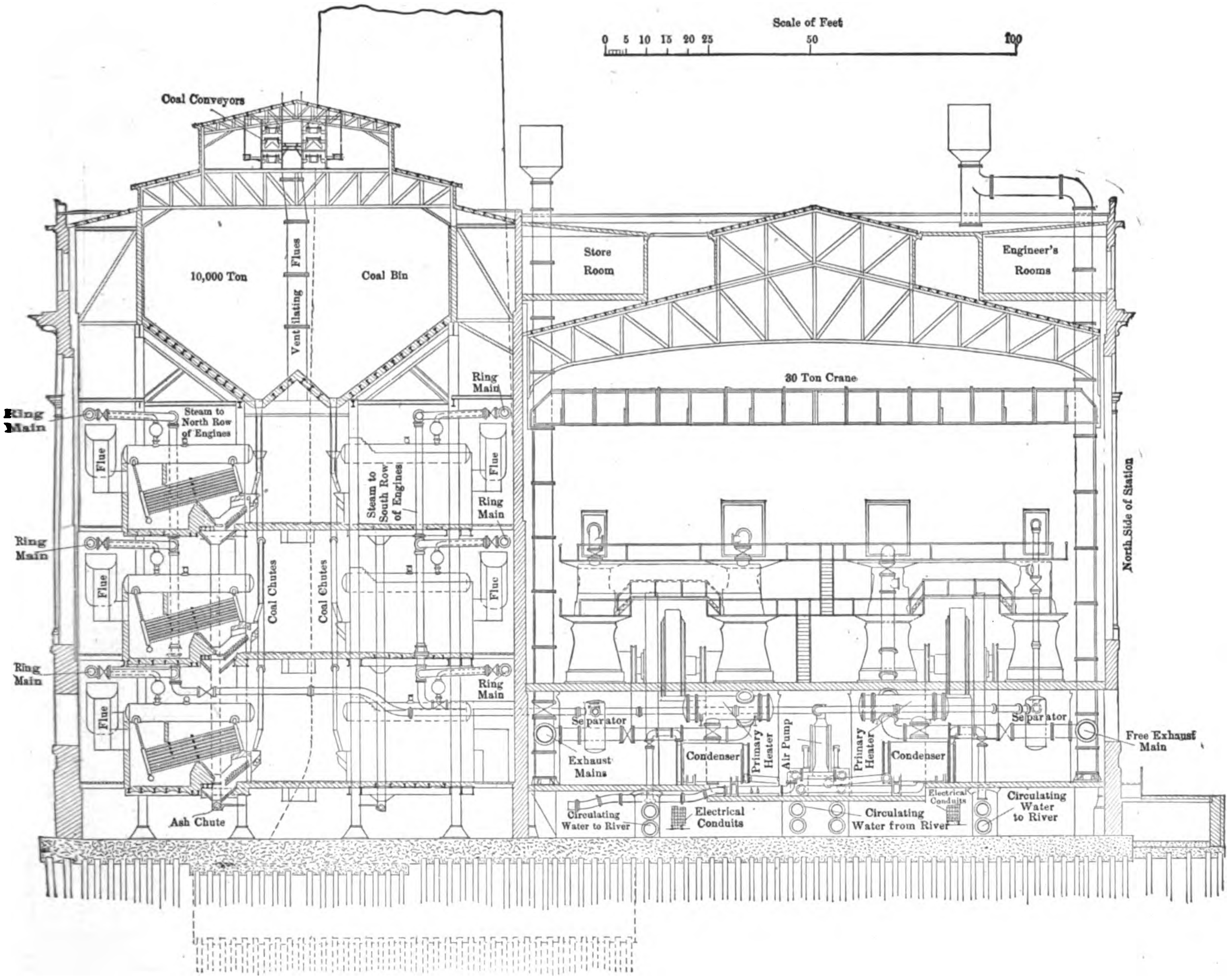

Scale of Feet
0 5 10 15 20 25 50 100
Coal Conveyors
10,000 Ton
Ventilating Flues
Coal Bin
Store Room
Engineer's Rooms
30 Ton Crane
Ring Main
Steam to North Row of Engines
Flue
Steam to South Row of Engines
Coal Chutes
Ash Chute
North Side of Station
Separator
Exhaust Mains
Condenser
Primary Heater
Air Pump
Free Exhaust Main
Circulating Water to River
Electrical Conduits
Circulating Water from River

FIG. 2.—SECTIONAL ELEVATION THROUGH THE BOILER AND ENGINE ROOMS OF THE POWER HOUSE.

THE BOILER, FLUES AND CHIMNEY.

Each boiler-room level contains 29 Babcock & Wilcox boilers having a rated capacity of 250 h.p. each, and an overload capacity of 400 h.p. each, at the normal pressure of the station, 160 pounds. Thus the 87 boilers give a rated capacity of over 20,000 boiler h.p. and an overload capacity of about 35,000 boiler h.p. This is based on the centennial rating of 30 pounds of water per i.h.p. of the engine, and as the engines used here will consume only about one-third of this, there is sufficient boiler capacity for something in the neighborhood of 100,000 i.h.p.

The boilers are supported on steel beams resting on the steel structure of the building and were, in fact, to a large extent installed before the brick walls were put in place. Most of the boilers are equipped with Roney mechanical stokers, though a few have Box stokers and a few are hand fired.

The gases from the boilers are collected by trunk flues running behind the boilers and delivered to the chimney. The latter is one of the notable features of the whole plant, being probably the largest in the world and the tallest on this continent. It is 353 feet in height with a 22-foot bore. On account of its tremendous weight, some 8,500 tons, great care was taken in the preparation of its foundation. Over 1,300 piles were driven in a space about 85 feet square and capped with a block of concrete 85x85 feet in plan and 20 feet deep.

THE STEAM AND WATER PIPING.

A reference to the plan of the station will indicate the arrangement of the live-steam piping. Completely contained within the boiler room on each tier there are two ring mains, one surrounding those boilers to the west of the chimney and the other surrounding those to the east of the chimney. These two rings are connected to each other at one point in front of the chimney. There is no ring main around the engines, and each engine has

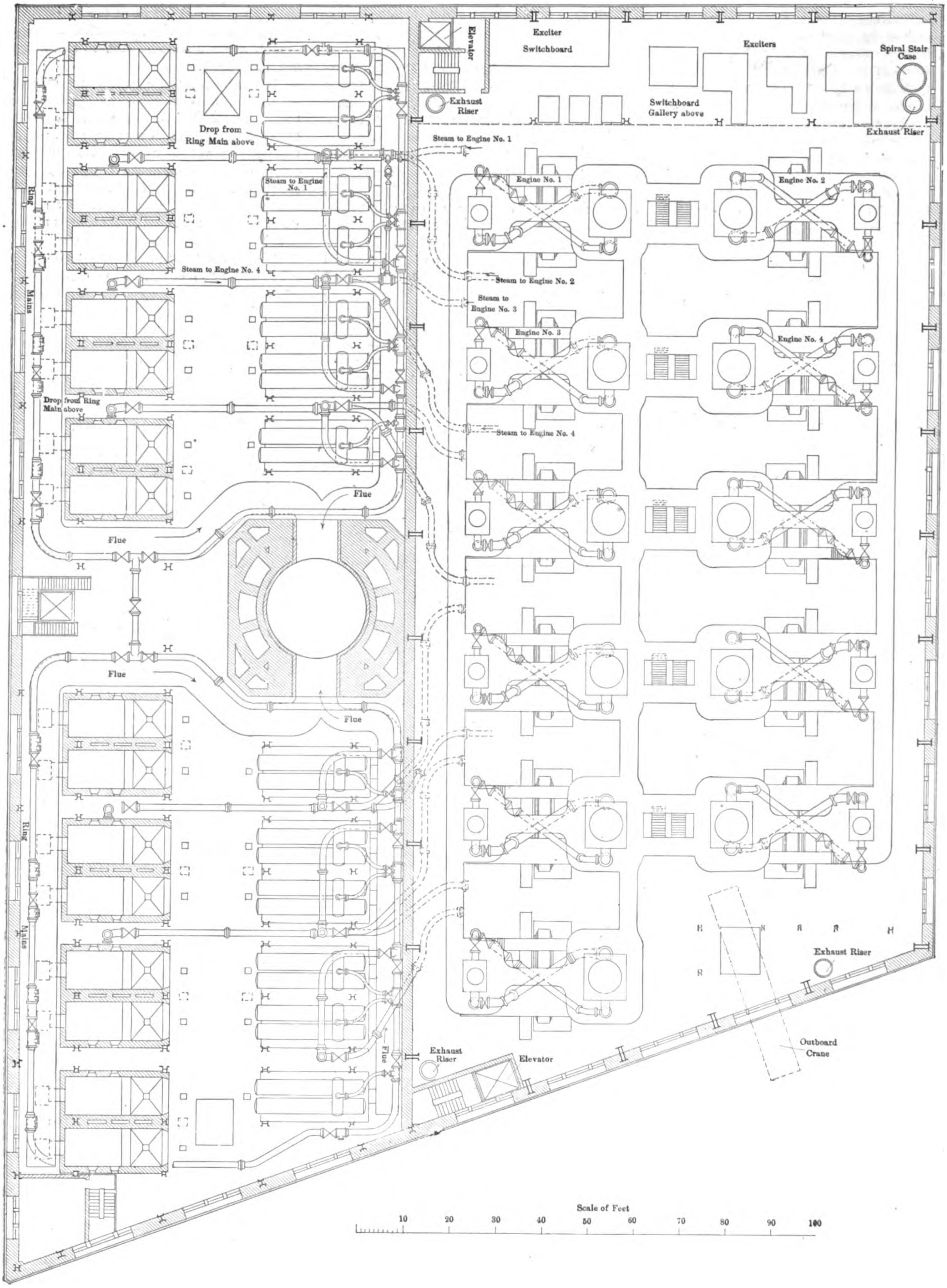

Elevator
Exciter Switchboard
Exciters
Spiral Stair Case
Exhaust Riser
Switchboard Gallery above
Exhaust Riser
Drop from Ring Main above
Steam to Engine No. 1
Steam to Engine No. 1
Engine No. 1
Engine No. 2
Steam to Engine No. 4
Steam to Engine No. 2
Steam to Engine No. 3
Engine No. 3
Engine No. 4
Ring Mains
Drop from Ring Main above
Steam to Engine No. 4
Flue
Flue
Flue
Flue
Ring Mains
Flue
Exhaust Riser
Exhaust Riser
Elevator
Outboard Crane
Scale of Feet
10
20
30
40
50
60
70
80
90
100

FIG. 3.—PLAN OF BOILER AND GENERATOR ROOMS, METROPOLITAN POWER STATION.

only one pipe from the boiler rooms. This pipe starts as a vertical drop, passing down through the different boiler rooms and connected in to each of the three ring mains, one above the other. This vertical pipe runs down into the basement and thence to the separator of the engine. Thus the ring mains on the separate levels can be tied together by eleven vertical risers, each of which carries steam from the mains to one of the engines. An examination of the section of the station, Fig. 2, will make this arrangement of the live-steam piping more clear. The valve stems of all valves in the ring mains and in the branches from the boilers and to the engines are brought up through gratings on the level of the boiler-room floor above. These gratings form a continuous passageway under the flues, by which any valve can be immediately reached, doing away with the need of gearing the valves down to wheels at the floor levels below.

The exhaust from each engine passes down through a Goubert primary feed-water heater to a Worthington condenser located in the basement. A plan of one end of this basement under the engine room, showing the arrangement of this piping, is given in Fig. 5. It will be seen that this basement contains on the First

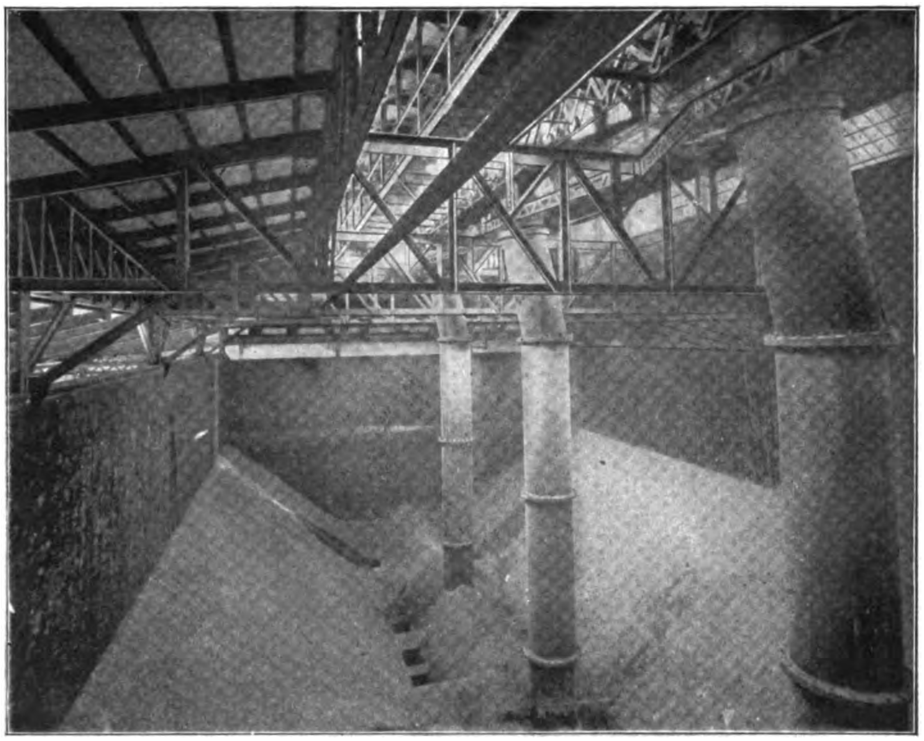


FIG. 4.—LOOKING INTO ONE OF THE 5000-TON COAL BINS. ABOVE ARE THE DUPLICATE COAL CONVEYORS.

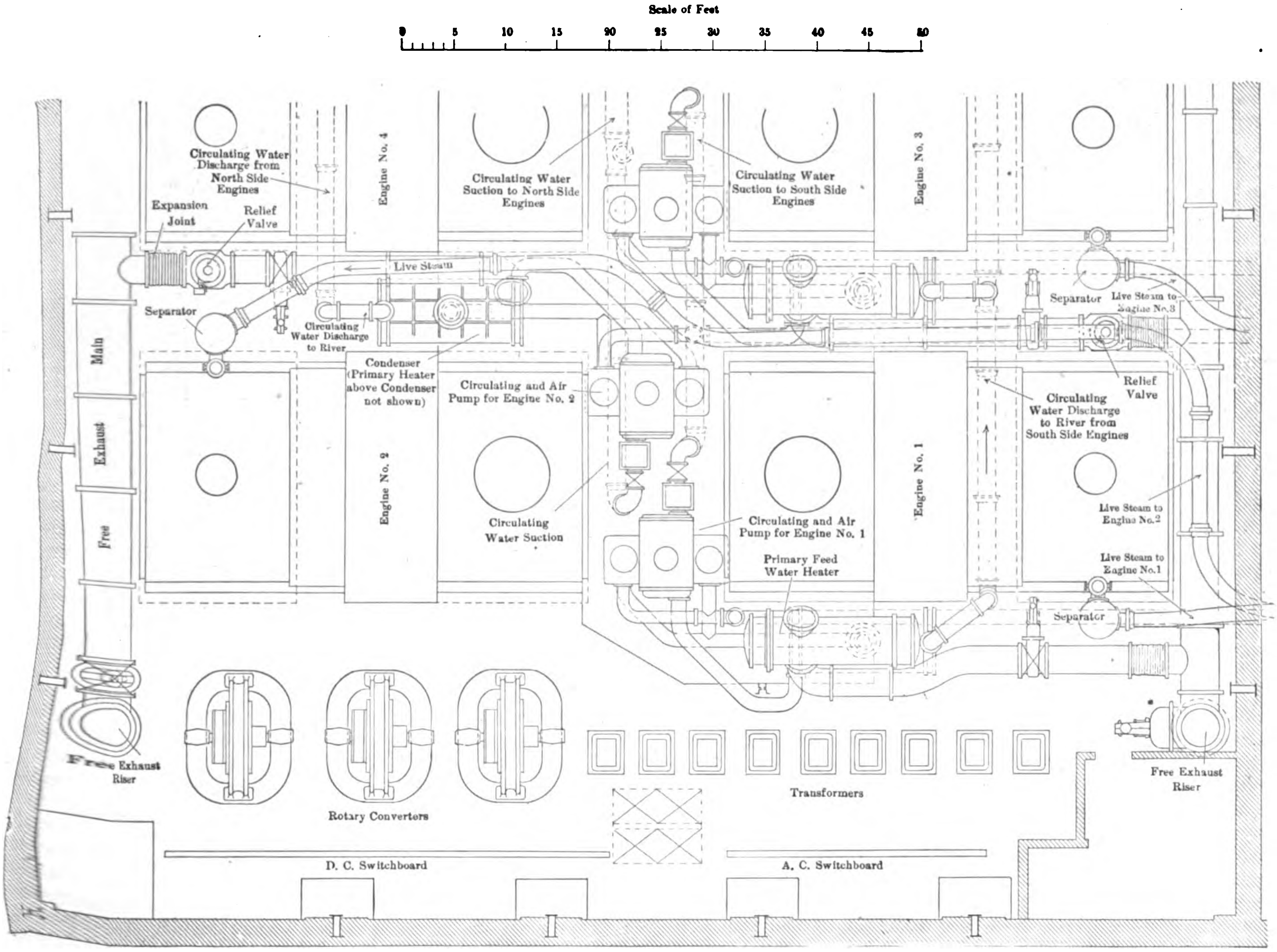

Scale of Feet
0
5
10
15
20
25
30
35
40
45
50
Circulating Water Discharge from North Side Engines
Expansion Joint
Relief Valve
Engine No. 4
Circulating Water Suction to North Side Engines
Circulating Water Suction to South Side Engines
Engine No. 3
Live Steam
Separator
Circulating Water Discharge to River
Condenser (Primary Heater above Condenser not shown)
Circulating and Air Pump for Engine No. 2
Separator
Live Steam to Engine No.3
Relief Valve
Circulating Water Discharge to River from South Side Engines
Main
Exhaust
Free
Engine No. 2
Circulating Water Suction
Circulating and Air Pump for Engine No. 1
Engine No. 1
Live Steam to Engine No.2
Primary Feed Water Heater
Live Steam to Engine No.1
Separator
Free Exhaust Riser
Free Exhaust Riser
Transformers
Rotary Converters
D. C. Switchboard
A. C. Switchboard

FIG. 5.—PLAN OF ONE END OF THE ENGINE-ROOM BASEMENT, SHOWING THE ROTARY CONVERTER SUB-STATION AND LAY OUT OF THE HEAVY PIPING.

Avenue side one of the rotary-converter sub-stations. To trace the course of the piping, attention is called first to engine No. 1, in the lower right-hand corner of the cut. The exhaust of this engine passes down into the primary feed-water heater, which appears on the side of the engine toward the sub-station transformers. Immediately under this feed-water heater, indicated by dotted lines, is the surface condenser. To the left of this engine are two combined air and circulating pumps of the vertical Allis type, with Corliss gear and fly wheels. That toward the sub-station is for engine No. 1, while the other serves for engine No. 2, each main engine having its own independent condenser, air pump, etc. From the primary heater the exhaust can be discharged to exhaust mains running along the side walls of the basement, which discharge into risers which carry the exhaust above the roof. The circulating water is brought in from the river through four 30-inch cast-iron pipes running the length of the station in the sub-basement, under the air pumps. It is taken from these pipes through fish traps into the circulating pumps, as Fig. 5 shows, and passed through the condensers into the circulating-water discharge mains, consisting of four 30-inch cast-iron pipes running back to the river. It will be seen from Fig. 5 that the primary heaters and condensers of all engines on the south side of the engine room are located to the west of their respective engines, while these auxiliaries of the north-side engines are in each case to the east of their respective engines. This gives an odd oblique direction to the piping throughout this basement. This unusual arrangement is accounted for by the fact that the northeast corner of the station is cut o.: by the angular direction of the river front (see Fig. 3) and the consequent fact that there are five engines in the north row and six in the south row.

From the air pumps the condensed water is carried to hot wells in the basement under the boiler rooms, there being one hot well for each engine. From these hot wells it is collected in two equalizing tanks, from which it is drawn by the boiler feed pumps. Between the equalizing tanks and the pumps the water is passed out to the primary heaters, and between the pumps and the boilers it passes through secondary heaters taking the non-condensed exhaust of the numerous steam auxiliaries.

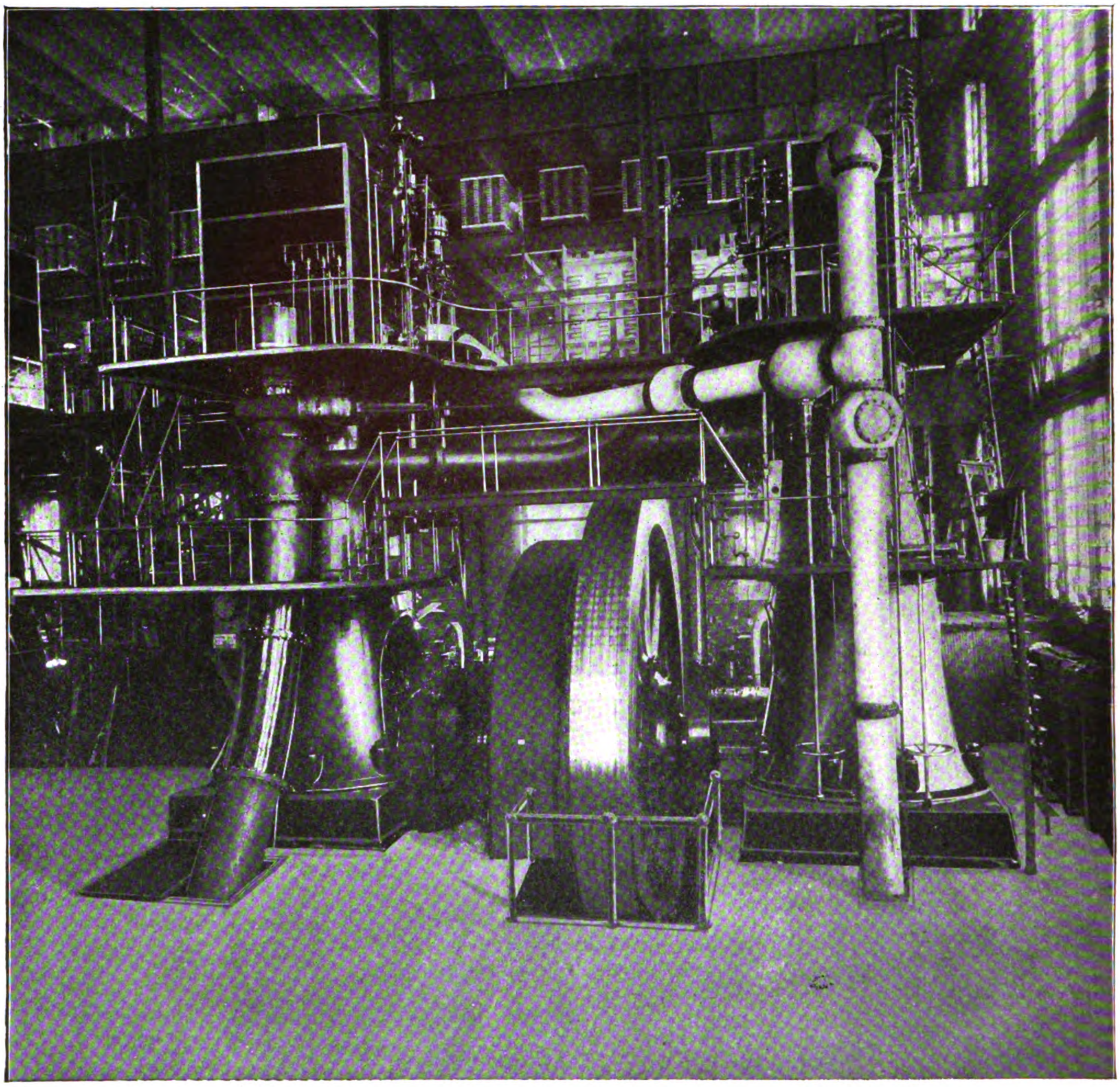


FIG. 6.—VIEW OF ONE OF THE GENERATING UNITS LOOKING TOWARD THE SWITCHBOARD GALLERIES.

THE MAIN ENGINES.

The engines, which were built by the E. P. Allis Company, are, as noted above, vertical cross-compounds, capable of giving 4500 h.p. at one-quarter cut-off, but able to work continuously at 6000 h.p. and for short periods at even greater powers. They are thus the largest engines ever built for driving electrical machinery and are among the largest engines ever built in this country for any purpose. To get an idea of their magnitude the horse power of a few other large engines built in this country might be mentioned. A blowing engine at the works of the Bethlehem Steel Company can, it is claimed, be run up to a maximum of about 15,000 h.p., or twice the maximum power of one of these engines. Each engine of the steamships "St. Louis" and "St. Paul" gives about 10,000 h.p. A hoisting and air-compressing engine of the Calumet & Hecla Company, in northern Michigan, is capable of delivering 6500 h.p. Engines for electrical purposes that approach those of the Metropolitan Company in size are as follows: One rated at 4000 h.p. at the cut-off of maximum efficiency, which is being built for the Boston Elevated Railway. This engine is very similar to the Metropolitan engines, being a vertical cross-compound Corliss, with cylinders 42 inches and 90 inches in diameter and a 5-foot stroke running at 75 r.p.m., while the Metropolitan engines have the same stroke and same speed, their cylinders being 46 and 86 inches in diameter. This Boston engine will drive a direct-current generator. Another Corliss engine, in the power plant of the Cleveland Electric Railway Company, has the same stroke and same number of revolutions per minute, its cylinders having diameters of 40 and 68 inches, the engine being rated at 3500 h.p. and capable of working up to nearly 5000 h.p. for short periods.

The most interesting points in the construction of the Metropolitan engines are as follows: They are of the two-bearing type with overhanging cranks. The engine shaft is of fluid compressed steel, forged hollow on a mandrel. It is 30 inches in diameter at the cranks and 37 inches at the central portion, where it is keyed to the fly-wheel hub and generator spider. The center hole is 16 inches in diameter. The fly wheel is 28 feet in diameter, built up of cast-steel sections, each consisting of one spoke and part of the rim. The weight of the fly-wheel rim is brought up to 200,000 pounds by the addition of several layers of 1⅛-inch steel plates on either side of the cast-steel segmental center of the wheel rim, the plates and castings being all firmly fastened together by 3-inch rivets. The hub of the fly wheel, in which the separately-cast spokes are fastened, is bolted directly to the spider of the revolving field of the generator, so that any heavy rush of power need not be transmitted through the keys and shaft, where it would cause great strains on account of the comparatively small diameter. The hub of the fly wheel, the spider of the generator, and the two cranks were, after shipment to New York City, forced upon the shaft by means of special hydraulic apparatus, giving a pressure of 11,000 pounds per square inch.

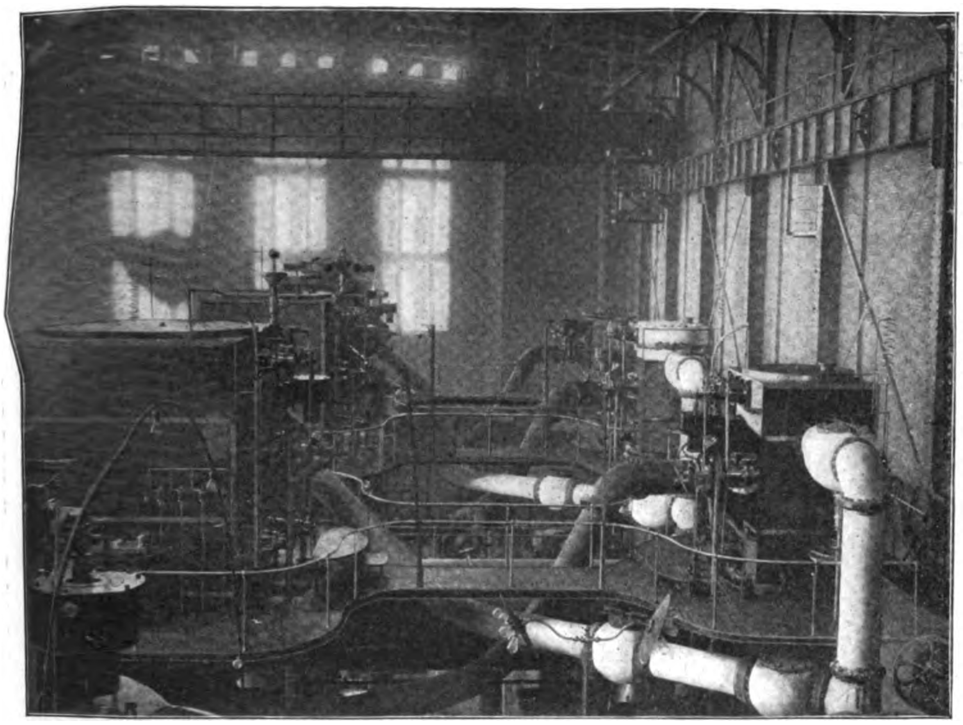


FIG. 7.—LOOKING FROM ONE OF THE SWITCHBOARD GALLERIES ACROSS THE TOPS OF THREE ENGINES.

The height of the engines from the foundations to the top of the cylinder heads is over 38 feet. The valves are of the usual Corliss type, but differ from ordinary practice in that they are placed in the cylinder heads in order to reduce clearance. One governor controls the cut-off of both the high and low-pressure cylinders, a separate emergency governor being installed, as usual, to cut off the steam in case the engine exceeds its normal speed by a certain amount. The high-pressure cylinder is connected to the exhaust pipe and the low-pressure cylinder is connected to the steam pipe, so that either half of the engine can be run singly if desired. The arrangement of these cross-connecting pipes is illustrated in the photographic illustration, Fig. 7. No steam jackets are used, but the receiver provides reheating by means of live steam.

A 220-VOLT TWO-WIRE ALTERNATING CURRENT CENTRAL STATION.

BY W. U. ZURFLUH.

During the past years the writer has made a specialty of contracting for and installing electric-light and power plants in small towns. In most of these places the plants have been installed by some local business man with a mill or factory, or have been put in by the municipality itself by the issuance of bonds. The systems have invariably been some form of arc lighting, mostly 220-volt d. c. enclosed arcs. One exception to this system, however, was installed and placed in operation on the sixth of last June, which is of rather unusual interest. The plant is at Rockford, Ohio, a town of some fifteen hundred people, and is on the Cincinnati Northern R. R. south of Van Wert, Ohio. The plant was installed by a local company comprising forty of the business men of the town, and was capitalized at $6,000, one of the unique points being that no one person was allowed to subscribe for more than three shares of stock at $100 per share. The plant having so many stockholders, who were practically the controlling taxpayers of the town, was as near a municipal plant as could be wished and that without bonding the town for one dollar. The town was bonded some years ago for water-works and has a fine water plant that would do credit to many a place of greater population. This water plant was leased from the town for a term of ten years, during which time the entire water and light plant is under control of the electric company.

Instead of putting in a dozen or more arc lamps which would scarcely cover the business part of the town, an incandescent system with seventy-three 32-c. p. lamps was used, a lamp being placed at each street crossing and alley. The power is supplied by one 90-h. p. McEwen engine, belted to a 60-kw. Warren inductor alternator. The boilers are the ones originally installed by the water-works board and consist of two domeless 45-h.p. return tubular boilers upon which the electric light company has placed domes. The dynamo is a 220-volt machine of the make above mentioned and is an innovation in the use of alternating current at this voltage. It is a very flexible unit, as by means of step-up transformers the current can easily be boosted up to provide for any long-distance extension to the town. At the present time no transformers are used. The pole line has two circuits, one for commercial service and one for street service. The system is of the interconnected type in which the mains run to the center of distribution about twelve hundred feet from the power-house and then branch to the various parts of the town.

At each street crossing the lines are interconnected, thus equalizing the voltage in the various circuits. All street lamps are connected "in multiple" and are protected by hoods from the weather and by porcelain fuse-blocks from short circuits and grounds. The poles are twenty-five feet in height and the lamps hang from eighteen to twenty feet from the roadway.

When the plant was installed the writer had many doubts as to its satisfactory reception by the public. But after operating for seven months the following was received from D. H. Robinson, President of the Rockford Electric Company:

"As to the plan and equalization of power, size of wire, etc., we do not think this plant can be improved upon. Everybody who takes our lights is delighted. Our street lighting is very satisfactory, no complaints, no arc lights wanted. Our visitors from other cities having arcs say we light our streets better than arcs would do. We now have seven hundred lights on and more coming on every week."

The following, also from the same letter, gives an idea of their plan, also cost per light to town: The city pays 80 cents per light per month for 32-c.p. and takes seventy-three lights. The Electric Light Company has a ten-years' lease of the water-works grounds and buildings, boilers and all machinery. Each company keeps its own machinery in order, except such as is used jointly, as boilers, boiler pumps, heater, etc. In this case each company pays one-half of the expenses for the use of the above-named water-works property. The light company does all the pumping of water for the town, free of charge; also provides oil, fuel, and man to run the plant. The plant runs until midnight for six months of the year, and for the other six months runs in the morning also, from four until seven o'clock.

In regard to the life of the 220-volt 32-c.p. lamps, out of seventy-three originally installed, but nineteen have been replaced after seven months' operation. The plant has run every dark night, which means at least eleven hundred hours of actual burning. This was a surprise, as a life of only three months had been guaranteed for the street lights.

The fuel used is four-foot wood at $1.50 per cord, and averages not over 1¼ cords per day for the winter—which can be safely put at one cord per day throughout the year.

This enterprising town has shown an example by which many other towns of the same size might profit.

This plan has the following strong points:

1. It enables a town to build a plant without bonds.
2. Does not bear hard on a few stockholders, if a failure.
3. Many stockholders make so many customers for the plant.
4. The system of lighting is very cheap, yet much more efficient than gas or gasoline.
5. Small cost of lamp renewals.
6. Will be better managed than a municipal plant.

A few changes of minor importance could be suggested and could easily be made without materially changing the plan. Thirty-foot poles and larger boilers would be better. However, in many ways this plant is a model.

THE LAMP-TESTING DEPARTMENT OF THE NEW ORLEANS EDISON COMPANY.

BY LYMAN C. REED.

The commercial photometering of incandescent lamps by central stations is a practice steadily growing in favor and use. The question of its economy has long since been settled favorably to the practice, so that considerations of this character will in this discussion be subordinated to the technical side of the question. The word "commercial" is used advisedly, to denote a difference between laboratory and commercial testing of lamps.

In order to make the photometering of lamps by a central station economical, it must be done quickly, and at the same time with sufficient accuracy to make the results of value. There are many classes of photometers on the market more or less simple in their structure, any one of which may be chosen to do the work. A simple Bunsen screen is accurate enough for the character of the work to be described, and is by far the quickest to read.

It is possible now to secure standard 16-c.p. lamps from the maker, which have a low efficiency, but retain a constant candle power for an indefinite period. The same quality of light shining on both sides of the screen gives the best results, and hence it has been found preferable to use a standard 16-c.p. lamp as the testing standard instead of an oil or gas flame. This standard lamp must burn at a fixed voltage, or at the same relative voltage as the lamp to be tested. In the latter case, the "same circuit" method* of connecting the two lamps is used, and will give fairly accurate results over a considerable range of variation in voltage.

The writer has found that the ideal method is to have a small storage battery of sufficient capacity and voltage to furnish a three-wire circuit of double the voltage needed. The standard lamp is connected on one side of the system, and the lamp to be tested on the other. In this way, the standard lamp is maintained at an absolutely constant voltage, and the lamp to be tested likewise receives a voltage subject to no variation. A rheostat in series with each lamp allows the voltage to be independently regulated to the desired pressures at which the two lamps should respectively burn.

The use of a storage battery for this work alone would hardly justify the expense of its installation, but there are many uses in the laboratory and meter testing room to which it can be daily put, making it an invaluable adjunct.

A view of the dark room in the meter department of the Edison Electric Company of New Orleans is shown in Fig. 1.

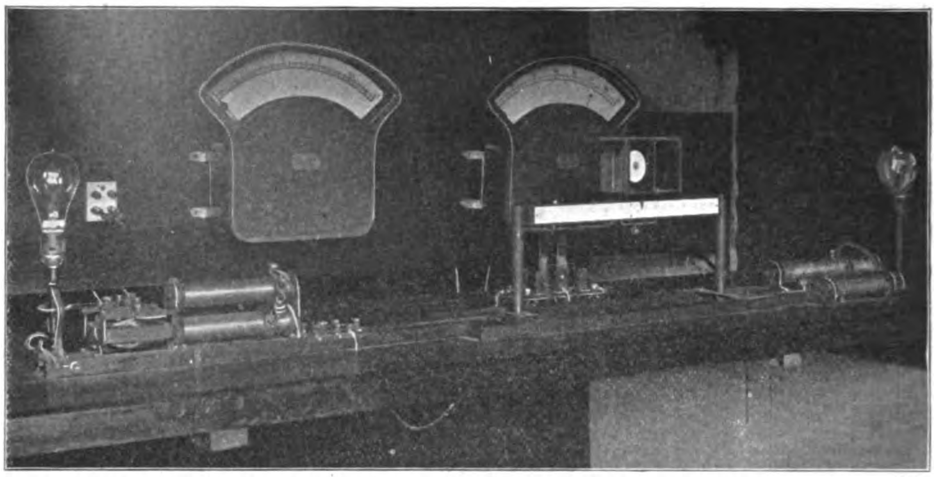


FIG. 1.—THE DARK ROOM, SHOWING PHOTOMETER AND METERS.

In the foreground is the photometer, on the left end of which is mounted the revolving socket, actuated by a small motor. On the right is a regular socket, containing the stationary standard lamp. The revolving socket is made specially with spring sides so that the lamp can be removed or put in while the socket is in motion, thereby reducing the time required for a test. Directly back of the sliding Bunsen screen are mounted the station type ammeter and voltmeter. The ammeter reads in 0.01 ampere divisions, and the voltmeter in large scale volts, the range being only from 90 to 125 volts. A throw-over switch enables the operator to place the voltmeter across either lamp socket, but when testing, the voltmeter is connected across the lamp to be tested.

It has been found that two can accomplish far more work in a given time than one in double the time. The "reader," when familiar with the instrument, can easily keep up with the quickest handling of the lamps by the boy at the revolving socket.

All the lamps, such as "cut offs," "renewals," etc., are passed through the photometer each month, and those of any value are retained for further use. The lamps are classified into two qualities of stock, first and second class. Those of the first class have a mean spherical c.p. of 16 and over, and are within the wattage range allowed to them. The second class may be taken as lying between 13 or 14 c.p. and 16 c.p. This latter class may be used for displays and outdoor work where a new lamp or one of high candle power is not particularly desired. Each lamp testing above the lower c.p. is subjected to another test, this final test separating the 16-c.p. from the 13-c.p. lamps.

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* For an explanation of this method see the American Electrician of October, 1899, page 463. —Editor.

In operating the photometer the screen is set at 13 c.p. and all lamps over this are accepted, all under rejected. Going over them the second time the screen is placed at 16 c.p. and all lamps under are left to the second grade. The lamps should be given a preliminary cleaning so that the dirt will not interfere with the true candle power of the lamp.

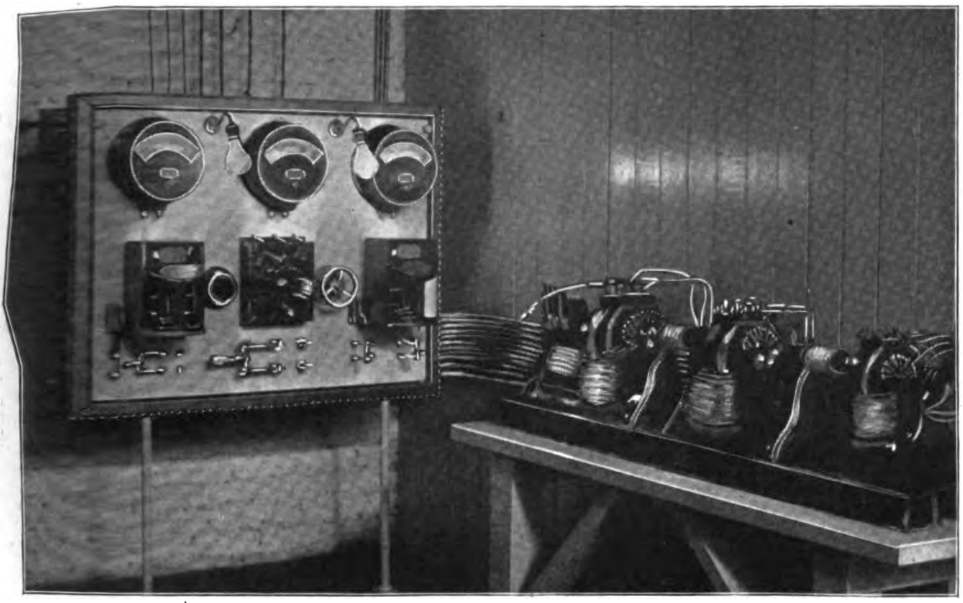


FIG. 2.—THE STORAGE BATTERY SWITCHBOARD AND CHARGING SET OF A PHOTOMETER EQUIPMENT.

The 16-c.p. lamp may be made to look as good as new by the following process: First the stubs are buffed, then the old labels are removed and the glass is thoroughly cleaned, after which new labels are put on. The finished product cannot be distinguished from new lamps. It is unnecessary to treat the second grade in this way, the only thing necessary being to see that the glass is clean. A boy can buff and clean four to five hundred lamps per day at a cost per lamp not exceeding ¼ cent.

In Fig. 2 a view is presented of the storage battery room and charging set used in this work. In the right foreground is the generating set, consisting of a motor in the middle, with a booster at one end and a low-voltage generator at the other. The booster raises the voltage from the line 50 volts, and charges 128 cells which have a capacity of 1¼ amperes for eight hours. One large cell of 70 amperes for eight hours capacity is used in meter testing, the low-voltage generator above referred to charging it.

The switchboard has the usual instruments, rheostats, switches, etc. Two recording wattmeters register respectively input and output of the storage cells, the difference less the percentage efficiency being the amount always on hand in the battery. Distributing leads from this board carry the current to the dark room and meter-testing room, the circuits being controlled by double-throw switches.

It is always well to have a higher voltage in the battery than that needed at the lamps, as then the battery can be fully discharged. In other words, the battery should have sufficient voltage at 1.8 volts per cell to meet the requirements of the lamps used by the central station. The different sizes of lamps are treated in the same manner as those of 16 c.p., the same relative value of candle power for first and second grade being maintained for all sizes.

With "bureau-tested" lamps, it is doubtful whether testing new lamps would result in any advantage. The chief use of a photometer in central-station work is to guard against any loss due to careless renewals of lamps. It is a common practice to renew lamps freely, while very often the cause of poor light is dirt or a low voltage due to an overloaded circuit. A large percentage of lamps thus renewed have a high candle power, the promiscuous rejection of which entails unnecessary loss.

Lamps cut off owing to discontinuance of service cannot be put in new stock. There are in large installations, especially in residences, lamps that are lit only for a few hours a year, and hence are practically new when cut off. Therefore all renewals and cut-offs should be photometered, the good lamps being divided into two classes as above indicated. The expense of the lamp account is then confined to installations, actual burned-out lamps and the renewal of those under 13 c.p.

The benefits of this system are so apparent that they need hardly be emphasized. The lamp-renewal account can be reduced fully twenty per cent. and renewals indulged in freely with the full assurance that the photometer will faithfully check up an otherwise unavoidable waste.

THE EFFECT OF JOINT RESISTANCE ON RAILWAY ELECTROLYSIS.

BY A. A. KNUDSON.

I have read with interest in the February number of the American Electrician the article by Mr. C. A. Newbaker entitled "Cure of Electrolysis by Independent Returns." As I have been largely engaged in electrolysis investigation, I think a few facts which have been gleaned from experience may be of interest and will tend to show that the independent return is not in all cases the absolute cure for electrolysis, as some believe.

The point I would advance is one which I think has not been given the importance it deserves in the past by those who have studied this question. I refer to the effect of joint resistance. In the case of cable sheaths there is, of course, no fear of trouble from this cause, but with water pipes, gas pipes and Edison tubes it is ever present.

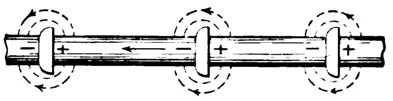
Mr. I. H. Farnham, in his paper on "Electrolytic Effects," before the American Institute of Electrical Engineers, in 1894, is the first, so far as I know, to call attention to this effect of joint resistance, where he says:

"Recent measurements, however, made in Boston, and others made in Albany, during the latter part of March, this year, convince me that there is a very appreciable resistance in such joints."

I have measured a number of joints in water mains, and generally have found their resistance to be proportional to the length of time they have been in the ground. This would seem reasonable when we consider the construction of these joints. The pipe lengths are treated with an asphalt varnish both inside and out, so that the ends, when placed together, are practically insulated from each other; when the melted lead is poured in the varnish is not impaired at all by the heat, as has been proved by actual investigation. Furthermore, (and this point has a bearing on resistance increasing with age) if the lead does touch the iron through the process of caulking, we know that lead and iron are wide apart in the galvanic scale and that moisture, ever present about water pipes, furnishes the remaining element to cause galvanic action, and consequently corrosion and increase in resistance year by year. To the galvanic effect of placing together two dissimilar metals (lead and iron) must also be added the additional corrosive effect of more or less railway currents passing through these joints. The effect of such resistance is to cause the current passing through such mains to leave the positive end of the pipe and pass through the earth around the joint to the end of the next length, or it may pass through the water on the inside and thereby cause damage through electrolytic pittings, or reduce the iron to a condition of graphite—which I have often seen—where it leaves the pipe, both inside and outside. So far as I am aware, Prof. Lucien I. Blake of the University of Kansas was the first to discover damage to the interior of pipes, at an investigation made at Kansas City. Mr. Farnham, however, mentions this possibility in his paper, where he refers to "breaking the metallic continuity," he says: "In case of water pipes treated in this manner, the action might be expected on the interior as well as the exterior." This would apply as well to a high-resistance joint as though it were intentionally insulated.

The accompanying diagram will give an idea of the shunting effect of the current at joints where the resistance may be high compared with that of the surrounding earth.

Referring to the feature, increase in resistance of pipe joints the longer they lie in the earth, we have the results of experiment to show that there can be no doubt on this point. Associated with others, the writer conducted the following tests on a number of pipe joints connected up for the purpose. There were four sections, two of four inches and two of six inches; in all there were 27 joints, made the same as in practice, with lead, and caulked. Measurements were taken to ascertain the resistance of every one of these joints, which were carefully numbered, and the results were tabulated. Eleven months later, measurements were again taken, and the result, when compared with previous tests, showed quite a remarkable change; nearly all were higher. Some had doubled in resistance, others trebled, while some had become over sixty times higher during the period of less than one year.



THE FLOW OF CURRENT AROUND RESISTING JOINTS.

This feature of joint resistance and the continual increase of such joint resistance the longer the pipes are in the ground being a well established fact, it would seem that such methods as "independent returns," which involve conducting the railway current through the pipes, are by no means the cure which some advocate. As a summary, therefore, it appears that the age of pipes is an important factor in determining the possibilities of electrolytic damage at or near the joints.

From my own observations I should say that pipes that have lain in the ground five years, or longer, should not be connected with systems intended as cures which involve current-flow through them. In other words, the older the water pipe, the less able is it to carry current without damage to itself.

It is quite true that the "independent-return" method presents a relief from excessive damage to water mains for a period of time, or, in other words, postpones the evil day of reckoning into years, instead of months, but a "cure" must be absolute or it is not cure at all. Now in regard to the other method suggested in your editorial as more economical, etc., viz., the use of a generator of low voltage at the power station to lower the potential of the piping, etc., I do not know of any such system in use, but I have seen similar devices spoken of and illustrated in various publications by more than one during the past four years. The effect of such device would have precisely the same objection as the "independent return," namely, the joint-resistance effect; in other words, any method which compels the water pipes of a city to act as a return conductor for railroad circuits is wrong in principle, to begin with, and detrimental to the piping system in the long run.

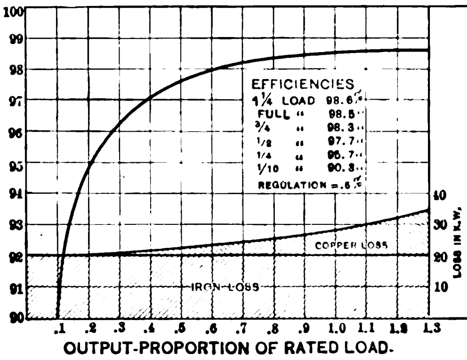


FIG. 1.—CURVE FROM TRANSFORMER "B."

One of these methods which seems to be based on the same principle as that you mention, is illustrated and described by Messrs. A. V. Abbott and J. Glen Wray, on page 10, Pamphlet No. 5, issued by the Electrical Bureau of the National Board of Fire Underwriters, 1896. These gentlemen have this to say of it: "Such an arrangement of station machinery is undoubtedly a palliative. It is by no means a cure, for in case in any part of the pipe system there happens to be a high-resistance joint, such a joint would become a point of inflection in the current, being electro-positive on one side and electro-negative on the other side." If water and gas mains were continuous conductors, like lead-sheathed cables, having no joints, then the problem would be less difficult.

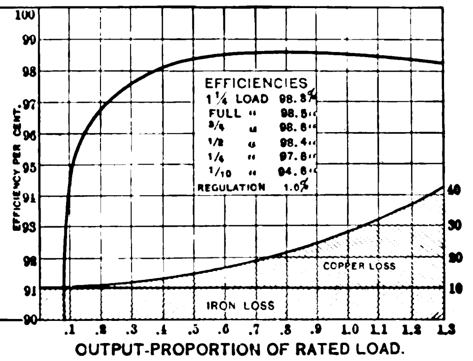
I think your correspondent in error, however, when he states "the independent return method of curing electrolysis, which has now been generally adopted through this country," etc. In my experience I have found more people opposed to this method than are for it, some for "joint-resistance" reasons which I have already mentioned. Others say the railway companies must find their own solution; that their water pipes have no business carrying heavy railway currents, and they were never intended for any such purpose.

It would seem, then, that for an absolute cure for electrolysis there is nothing in sight except to abandon the earth, as the telephone companies had to do when the trolleys came, and resort to metallic circuits, which means double overhead or underground systems. The double overhead is, of course, the least expensive, and has been in use much longer than the underground. Besides its long satisfactory use in Cincinnati, Ohio, it has recently been installed on some of the important lines in Washington, D. C. There is but little objection to the system, and it is not unlikely that other installations will be made in other cities.

THE ADVANTAGES OF TRANSFORMERS WITH HIGH CORE AND LOW COPPER LOSSES.

BY E. A. WAGNER.

Much has been said and written regarding the good qualities of low-core loss transformers and their desirability in almost any line of work. In certain classes of work, however, it is advantageous to use transformers having a high-core loss in preference to those with a low-core loss, the total losses at full load being equal.



American Electrician

FIG. 2.—CURVE FROM TRANSFORMER "A."

In designing transformers for a particular kind of work, to obtain the best all-day efficiency, a little study of the load variations will suffice to show what proportion the iron and copper losses should bear to each other in order to attain a maximum all-day efficiency.

If a transformer is to be used on a lighting or power circuit with 24-hour excitation and full or partial load for four or five hours only, then the transformer having the lowest core loss will have the highest all-day efficiency. Where the load is, however, nearly always at or above normal full load, as is required, for instance, at the various electrical furnaces at Niagara Falls, the high-core loss transformer has the advantages of ability to carry heavier overload without danger of overheating, better regulation at all loads and better efficiencies at overloads.

Figs. 1 and 2 show efficiency curves of a high and a low core loss transformer designed for 2500-h.p. output at 25 cycles.

Each transformer has a full-load efficiency of 98.5 per cent., and the full-load loss in each is 28.5 kw.

At 25 per cent. overload, the low-core loss transformer, which we will call "Transformer A," has a copper loss of 28.5 kw., or a total loss of 33.3 kw. This is an increase in the total losses of about 35 per cent. between full load and 25 per cent. overload. At the same overload the high-core loss transformer, which we will call "Transformer B," has a copper loss of 13.3 kw., or a total loss of 33.3 kw. This is an increase of only 17 per cent. in the total losses between full load and 25 per cent. overload.

From these figures it will be seen that "Transformer B" should be able to carry a much heavier overload without danger of overheating or burning out than "Transformer A," and at efficiencies as seen by the curves.

If the transformer is designed so as to have a core loss equal to its copper loss at full load, the efficiencies will average at loads below and above full load better than either of the cases shown, and in general it can be stated that the best practice is to design the transformer with the maximum efficiency at the average overload.

DOUBLE-WOUND ARMATURES.

ALTON D. ADAMS.

The class of double-wound armatures here considered is that in which each winding is entirely independent of the other and has its own commutator. Electrical machines with single magnet frames and double armature windings and commutators are especially suited to a variety of uses, notably in the small sizes. The distinctive features of these machines in every case are the single armature core and the one circle of magnet poles. According to their purposes, these machines with two armature windings and two commutators may be divided into four general classes. Class one may be taken to include those cases in which both armature windings receive electric current from some source of supply and enable the machine to act as a motor. In the second class, one armature winding takes current from an outside supply as a motor, and the other winding delivers a dynamo current to consuming devices. Class three is that in which both armature windings deliver current, the armature being driven by mechanical power. The fourth class includes machines with double-wound armatures, in which each winding alternately receives current to rotate the armature or delivers current and consumes the mechanical energy furnished at the moment by the other windings.

BOTH WINDINGS TAKING CURRENT.

Where both of the armature windings receive current from an outside source at the same time, so as to combine their motor actions, each winding is usually the exact duplicate of the other as to capacity in amperes and voltage. When each winding is connected directly to a circuit of the maximum pressure, the motor will operate at maximum speed, take the largest allowable current in amperes, and work at its greatest capacity. If now one winding is entirely disconnected from the supply circuit, the speed remains the same, but the current and work capacity are each reduced one-half. Where the two windings are connected in series so that the brush terminal of one winding that was formerly connected to the positive side of the supply circuit is now joined to the brush terminal of the other winding that was connected to the negative side of the supply circuit, the ampere capacity, work and speed of the motor on its former circuit is reduced by one-half. If this same motor, with the two armature windings joined in series, is connected to a supply line of double the former pressure, the ampere capacity of the motor remains as in the last case, but the speed and power capacity are doubled. In this last case the magnet coils must either be excited at constant pressure or else their connections must be changed for the higher pressure. It is possible for special purposes to so proportion the two armature windings that their capacities are unequal either as to amperes, volts for the same speed, or both. If the windings are equal as to ampere capacity, but not as to pressure, they should not be used in multiple but may well be connected in series. When either of these windings of unequal pressure capacity is connected to the supply line directly, the other winding remaining idle, the speed resulting is either greater or less than twice that when both windings were in series, but the capacity for work remains the same. This last arrangement of windings is suitable when it is desired that a motor to be operated from a single supply pressure, shall have either two or three speeds with any desired relation as to each other. If the two armature windings differ as to both volt and ampere capacities, they cannot be used in multiple, but each may be connected to the same circuit at different times for different speeds and capacities, or to different circuits for equal speeds and working outputs. On neither supposition of this last case can the motor operate at the combined capacity of both armature windings. The several windings and their combinations, just named, enable a single motor to operate at a variety of speeds or on circuits of different pressures without the constant use of external resistance.

ONE WINDING TAKING, THE OTHER DELIVERING CURRENTS.

A double-wound armature intended to receive current in one winding so as to drive the other winding while it delivers current, may have any desired relation between the volt or the ampere capacities of the two windings. As the energy sent into the motor winding must, in any case, equal that delivered by the dynamo winding, plus all losses in the armature and the bearings, the capacity of the motor winding should be slightly greater than that of the dynamo end. Machines of this kind have a useful application to a great variety of purposes, usually to take current from a source of supply at one pressure and to deliver current near the place of use at some other pressure. Among the transformations effected by these "dynamotors," as the machines with one motor and one dynamo winding on the same armature core are called, is that of energy from 500 to 110 volts for incandescent lighting, from 500, 220 or 110 volts to 5 or 10 volts for electro-plating or bell ringing, and to any desired pressure for battery charging and for use on telephone and telegraph lines. Except for the small influence due to internal losses, the product of the volt and ampere capacities of the motor winding should equal the similar product for the dynamo winding, so that in any case the ampere capacity of either winding will vary as to that of the other winding in nearly the inverse ratio of their voltage capacities. The magnet winding of the dynamotor is usually excited from the same source that supplies the armature motor winding, and as the magnet acts alike on both armature windings, the volts at the dynamo terminals cannot be regulated by changing the strength of the magnet coil, since this only varies the speed of revolution. The ratio between pressures at the terminals of the motor and of the dynamo coils is fixed by the proportions of their windings, but the ratio between the line pressure and that at the dynamo coils may be varied by a resistance inserted between one side of the line and the motor coils of the armature.

BOTH WINDINGS DELIVERING CURRENT.

A dynamo with two independent armature windings and two commutators may be used to deliver current at unequal pressures for different purposes, or on the three-wire system, where the total voltage is twice that of either winding. For an isolated plant on the three-wire system it is, at times, desirable to have the total capacity in one dynamo of moderate size instead of two small ones. Even in two-wire plants some lamps are so distant from the dynamo that it is best to select those of about 220 volts for these locations, in some cases, while lamps of about 110 volts are preferred for the remainder of the plant. Double windings with two commutators enable different circuits, some for 110 and others for 220-volt lamps, to be supplied from the same machine. Again, for some special class of work, a large amount of current, different in pressure from that used at the lamps, may be wanted, and the desire, perhaps, is to use one machine for both purposes, as can be done.

EACH WINDING ACTING TO RECEIVE OR DELIVER CURRENT.

Each set of coils on a double-wound armature may serve to alternately receive or deliver current, as desired, and machines with armatures intended for this action are used for purposes of regulation with three-wire systems. In order to regulate the pressures between the positive and neutral and between the neutral and negative of a three-wire system, the dynamotor may be connected in either of two ways. One of the armature windings may be connected from positive to neutral, and the other winding from neutral to negative, in which case the winding in contact with the higher pressure receives current and the winding in contact with the lower pressure delivers current, until the pressures of the two sides are equal. For the case just noted the two armature windings should have exactly the same volt and ampere capacities. Where one armature winding is connected to the positive and negative wires and the other winding to either the positive or the negative and neutral wires, the winding in contact with the positive and negative wires should have just twice the volt and one-half the ampere capacity of the other winding.

When the pressure between the positive and negative wires is more than twice as great as that between the connections of the low-pressure armature winding, the high-pressure winding takes current from the line and the low-pressure winding gives out current to its connections. When the pressure at the connections of the low-pressure winding is more than one-half as great as the pressure at the connections of the high-pressure winding, the low-pressure winding delivers current to its connections, until the low pressure is only one-half as great as the high pressure.

The capacity of a dynamotor, as gauged by the heating limit, is double that of each of its armature windings, so that a dynamotor of 10 kw. should absorb in one winding, or deliver from the other, only about 5 kw. In the regulation of a three-wire system there is an advantage with a dynamotor in which the two armature windings are equal and connected, one from the positive to the neutral, and the other from the neutral to the negative wire. Difference in the pressures between the two sides of the three-wire system results from unequal loads on these sides, and the dynamotor operates to maintain equal pressures by keeping the loads equal, so far as possible. Where the dynamotor is connected by one winding to the two outside wires of a three-wire system, and by the other winding to one outside wire and the neutral, any variation of the load between the outside and neutral wire to which one winding is connected, from the load between the other outside wire and the neutral, is made up by a transfer, either to or from the outside wires, of enough energy to leave equal loads between each outside wire and the neutral. As the dynamotor can transfer energy to an amount equal to only one-half of its total capacity, the method of connection just noted will correct unequal loads on the two sides of a three-wire system only to one-half of the capacity of the dynamotor used. If one of the armature windings is connected between the positive and neutral wire, and the other winding is connected between the negative and the neutral wire, the dynamotor will correct an inequality of load on the two sides of a three-wire system to an amount equal to the capacity of both dynamotor windings, since the capacity of one winding may be taken from the side where the pressure is high and the load light, while the capacity of the other winding is delivered to the other side, where the pressure is low and the load heavy.

CONSTRUCTIONS FOR DOUBLE-WOUND ARMATURES.

The single-magnet frame for a double-wound armature may be of either the bipolar or multipolar type, as desired, and the magnet windings may be arranged in a variety of ways. If the machine with double-wound armature is to be used as a motor, it is well to have the magnet windings so arranged that their connections may be changed for excitation at two or more pressures. Where it is desired that the magnet coils be excited at either 110 or 220 volts, or at any other two pressures that have the same ratio, it is only necessary that the magnet winding be divided into two equal parts so that these parts may be connected, either in series for the higher pressure, or in multiple for the lower. In dynamos wound for two voltages it is well to have the magnet winding arranged for excitation at either pressure, where it can be conveniently done. Double-wound dynamos may have a series-magnet winding connected to one or both sets of the armature coils, with results similar to those with single-wound armatures, and the same is true for double-wound motors. For the dynamotor, however, a series or compound winding will simply affect the speed of rotation, but cannot change the pressure generated in the coils used to deliver current, since a compounding coil can only cause the armature to run fast or slow, according to the strength of the magnet, so as to give the counter electro-motive force of the motor coils a certain relation to the pressure of the supply. While the two sets of coils on a double-wound armature are entirely insulated from each other, they may or may not occupy the same slots.

In the drum type of armature it seems better to have both sets of coils in the same slots, but in the gram core each coil may well have its own slot. Where the number of slots in armature cores equal the number of armature coils or of commutator segments, the number of coils per slot is two for the drum coil and one for the gram core, with a single winding. For this reason, among others, the gram coil is better adapted than the drum for double windings and commutators, especially in small sizes. Bipolar-magnet frames have some advantage for small double-wound gram armatures, because from 12 to 24 coils per pole are desirable for each armature winding, and the large number of slots, necessary in armatures for multipolar frames, result in machines of poor proportions. If quite a large difference exists between the voltages of the two sets of armature coils, it is all the more desirable that each set be wound in alternate slots, as insulation is then a simpler problem.

ADVANTAGE OF DOUBLE-ARMATURE WINDING.

Double armature windings for motors permit the variations of speed within their limits without the excessive loss of energy that results when an external resistance is used for purposes of regulation. The ability of a single motor to do its full work on either of the two standard voltages gives the machine a higher general value, and in some cases may enable one motor to take the place of two. A double-wound dynamo is often less expensive, more efficient and makes a saving as to space over two dynamos of the same capacities. Dynamotors are usually more efficient than motor-dynamos of equal capacity, because there is but one magnet frame to be excited, one armature core, and usually two less bearings than in a motor-dynamo. The winding losses on the dynamotor armature are also quite sure to be less than the sum of the winding losses on the two armatures of an equivalent motor-dynamo. Not the least valuable property of the dynamotor is its freedom from sparking or necessity for change in brush position on the commutator under different loads. The currents in the motor and in the dynamo coils on a dynamotor armature are equal and opposite in their tendency to distort the magnetic flux in the air gap, hence they offset each other and the brushes may remain in a fixed position.

DISADVANTAGES OF DYNAMOTORS.

Dynamotors are at a disadvantage as ordinarily built, compared with motor-dynamos, in that the ratio of transformation remains fixed and cannot be varied by a change of the magnet strength, as in the dynamo or motor of a motor-dynamo. In large dynamotors it is easy, however, to arrange small auxiliary magnet poles and a section of armature core to act on one set of coils only and give variable ratio of pressure. Another use to which the dynamotor has been put in a few cases, and one that may ultimately prove of general advantage, is the transformation of energy in the form of high-pressure direct current from transmission lines to low-pressure direct current for distribution lines. The dynamotor in this case takes a position similar to that of the alternating-current transformer, the rotation of the armature in the former serving the same purpose as the reversals of current in the primary winding of the latter. When it is used for such purposes, means can be adopted to vary the voltage at the low-pressure terminals of the dynamotor for purposes of regulation. It is not to be presumed that direct-current transmissions will ever become common over very great distances or at pressures higher than a few thousand volts, but a very large part of the electric work in towns and cities can be economically reached with currents of 2000 or 3000 volts, and the dynamotor may yet prove a useful device within these limits.

ELECTRICAL POWER IN THE GROSVENOR DALE COTTON MILLS.

The Grosvenor Dale Cotton Mills consist of three large buildings, each of which is situated near a separate fall along the stream. The upper fall has about 1100 h.p., the central one about 300 h.p., and the lower one about 450 h.p. The mill in the center was found to be too small to be operated with profit, and it was decided to dismantle it, and utilize the power of the fall for operating an electrical plant to supply light and auxiliary power for the other two mills. The conditions of the seasons made it judicious to select an electrical equipment, as during the summer months, when the water in the stream is low, a very small quantity of lighting is required, whereas in the winter, when the water supply is ample, both lighting and power can be amply supplied.

The contract for the electrical equipment was awarded to the Westinghouse Electric and Manufacturing Company. At the central station were placed two 150-kw., two-phase generators, delivering current at 2200 volts and 7200 alternations. A view of the central power house is shown in Fig. 1. The switchboard to the left of the engraving follows the usual Westinghouse practice. Two direct-current exciters supply current for the larger generators. At the lower mill, the 2200-volt current is passed through two transformers and stepped down to supply one thousand 16-c.p. incandescent lamps. At the upper mill are four transformers which step down part of the current for twenty-two hundred 16-c.p. incandescent lamps, and for several small Westinghouse "Type C" induction motors operating at 200 volts in the cotton house. At this mill are two 100-h.p. Westinghouse two-phase motors operating at 2000 volts, taking current direct from the generators at the central power station. These motors are belted direct to one of the main jack shafts, as shown in engraving Fig. 2. The conductors consist of four No. 6 wires to the lower mill, which is about 1800 feet distant, and four No. 4 wires to the upper mill, which is situated about 6000 feet from the central station.

The electrical equipment was guaranteed to operate successfully under a maximum variation of three per cent. in the speed of the engines at the upper mill and of five per cent. of the speed of the water wheels at the electric station. The results have proved entirely satisfactory, and the motors have often worked at from 30 to 40 per cent. overload. A steam engine has been placed at the central power station to enable the lighting circuits to be supplied when water power fails.

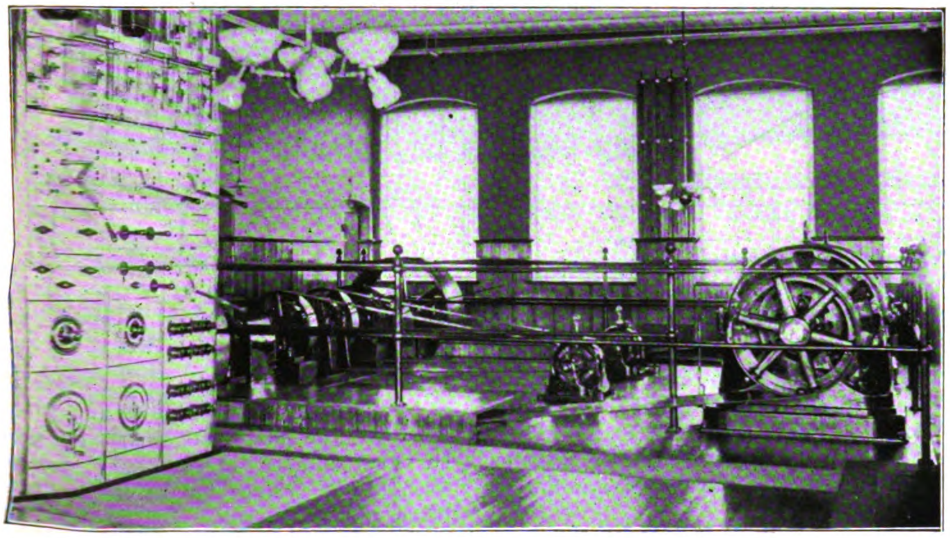


FIG. 1.—POWER HOUSE AT GROSVENOR DALE COTTON MILLS. TWO 150-KW. TWO-PHASE GENERATORS.

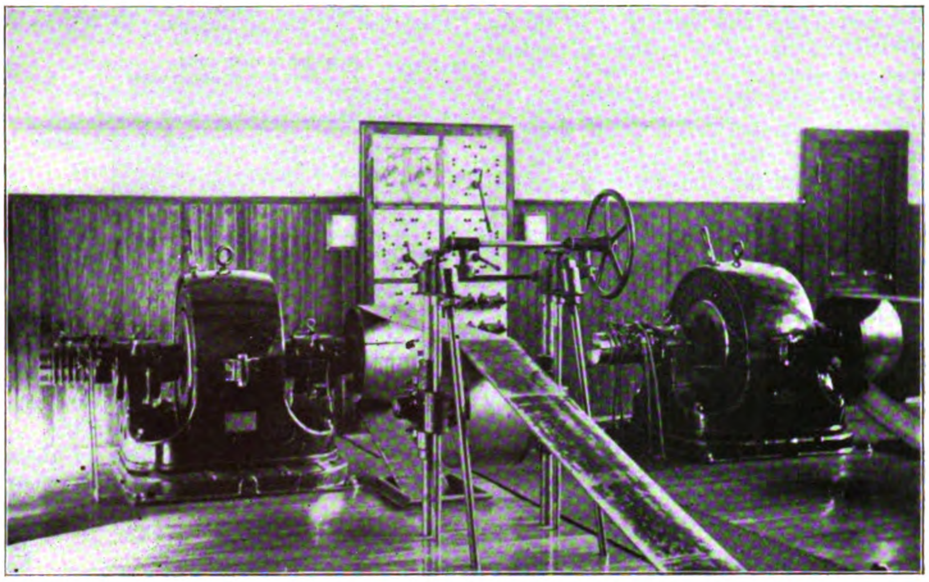


FIG. 2.—TWO 100-H.P. INDUCTION MOTORS OPERATING SHAFTING AND SERVING AT TIMES AS GENERATORS.

An interesting feature with regard to this plant is the double service supplied by the two 100-h.p. motors. It was customary at first to throw off the motors when the lights were turned on, as the wheel power was not sufficient for both, for as the demand for lighting current increased the wheel became overloaded, the speed fell off, and the voltage on the line was reduced. But as the motors are connected to the mill shafting, driven by a powerful engine, they are held up to their normal speed, and automatically reverse their action by acting as generators, delivering sufficient current into the line to maintain the voltage, and thus relieve the wheels, enabling them to keep up their normal speed. This feature affords a perfect automatic regulation, enabling the full power of the wheels to be utilized, the regulation of the voltage and the reverse action of the motors being perfectly automatic.

An electrical equipment offers many advantages in the operation of cotton mills, especially where, as in the case of the Grosvenor Dale mills, separate buildings require lighting and auxiliary power, in order to maintain full speed and product. It enables the generating apparatus to be concentrated in one place, as current is easily transmitted to several distant points. It also affords great economy in floor space, due to the absence of belt or rope drives and by the substitution for transmission purposes of wires, which are run overhead on the ceiling and occupy no valuable space. The electric lighting for all the mills is furnished by a small additional outlay as the current is supplied by the same generator as that which operates the motors. Induction motors can be operated harmlessly in the presence of inflammable and even explosive material, since there are no moving contacts to produce sparking. Perhaps one of the greatest advantages incidental to the introduction of electrical machinery into manufactories is the improved sanitary conditions for the employees. Not only is there ample light furnished at all hours, but the absence of dust, dirt and lint, which is being continually stirred up by belts, and the notable reduction in the noise of the factory, afford conditions which favorably affect both the quality and quantity of the output.

The Westinghouse-Parsons Steam Turbine.

For several years past, American engineers have heard much of the development in England of the steam turbine invented by Mr. Chas. A. Parsons, of Newcastle-on-Tyne, and especially of its application to marine work, such as torpedo-boat propulsion.

That a good steam turbine would be admirably adapted to electrical work occurs to every electrical engineer who has struggled with the difficulties of adapting dynamos to engine speeds. That the Parsons steam turbine has been applied to this class of work has also been evidenced by descriptions of English central stations and traction plants using this up-to-date machine as a prime mover. The statement recently appeared that the firm of C. A. Parsons & Company was building two complete turbo-alternators with a capacity of 1400 h.p. each for use in a municipal plant in Germany. These machines are the largest which the English firm has undertaken.

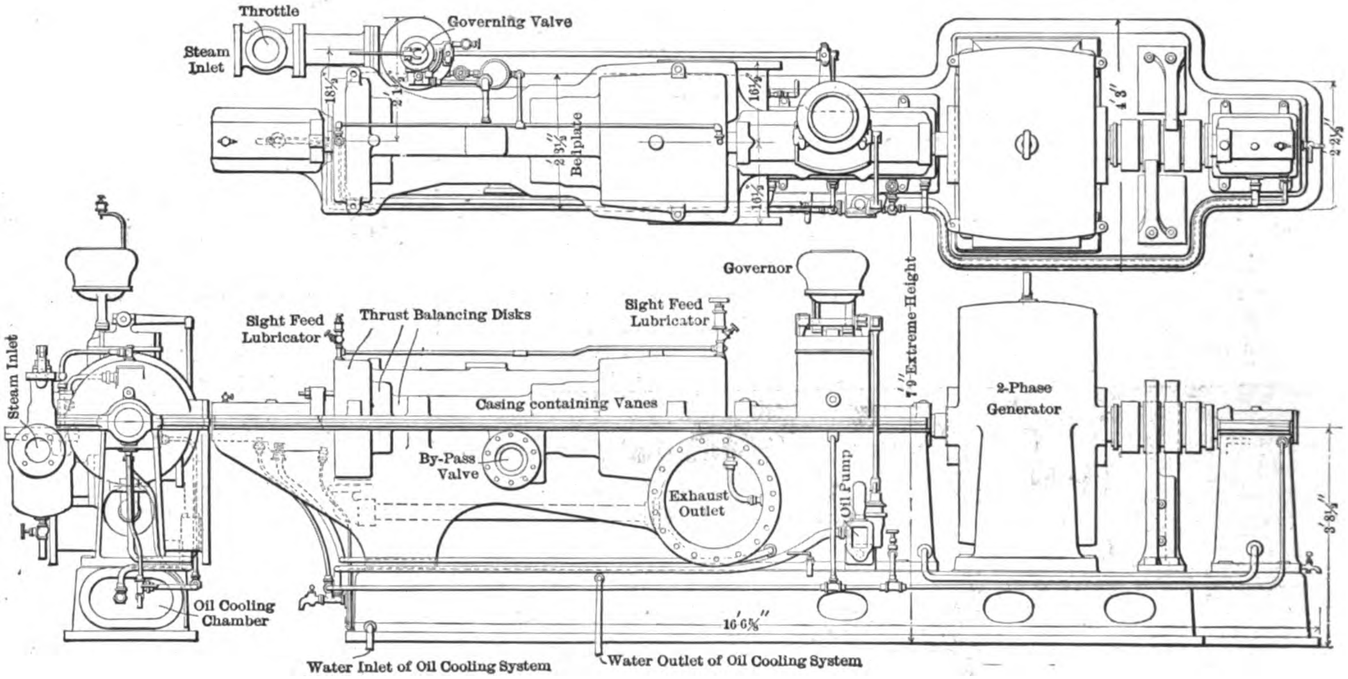

Throttle
Steam Inlet
Governing Valve
Oil
18½
2 1½
2 3½
Belplate
16½
16½
4 3"
2 2½"
Governor
Sight Feed Lubricator
Thrust Balancing Disks
Sight Feed Lubricator
7 9" Extreme Height
Steam Inlet
Casing containing Vanes
2-Phase Generator
By-Pass Valve
Exhaust Outlet
Oil Pump
3 8½"
Oil Cooling Chamber
16 6⅝"
Water Inlet of Oil Cooling System
Water Outlet of Oil Cooling System

FIG. 3.—PLAN AND ELEVATIONS OF 500-H. P. TURBINE AND ALTERNATOR ILLUSTRATED ON OPPOSITE PAGE.

That work in the same line has been for some time under way in this country has not been generally recognized owing to the quietness with which it has been carried on. The Westinghouse Machine Company of Pittsburgh is the American concern which is carrying on the development of this form of turbine on this side of the water. This company purchased the patent rights for the United States in 1896 and has been engaged for some time in developments which have brought out forms differing considerably in detail from those designed by the English company. The services of Mr. Francis Hodgkinson, an engineer who was identified with the development of the turbine in England, were secured by the American company and he is now in charge of the turbine work. This work has progressed so far that the company now has in operation in the power plant of the Westinghouse Air Brake Company at Wilmerding, Pa., three turbines rated at 500 h.p. each, besides which it is building a 2,500-h.p. turbine for the United Electric Light & Power Company of New York City.

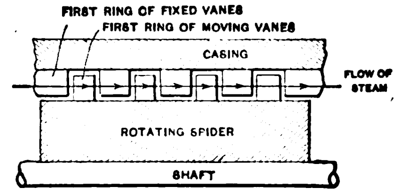

FIRST RING OF FIXED VANES
FIRST RING OF MOVING VANES
CASING
FLOW OF STEAM
ROTATING SPIDER
SHAFT

FIG 1.—SKETCH OF SECTION THROUGH TURBINE, SHOWING RELATIVE ARRANGEMENT OF FIXED AND MOVING VANES.

Before describing any details of these machines a short explanation of their principles may be in order, especially as the words "steam turbine" call to the minds of most American electrical engineers the De Laval type of machine, with which they have been familiarized through its trial some years ago by the New York Edison Company and the publication of descriptions occasioned by this introduction on American soil.

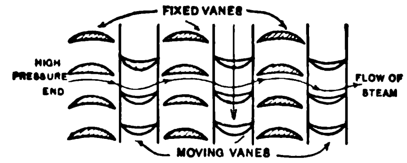

FIXED VANES
HIGH PRESSURE END
FLOW OF STEAM
MOVING VANES

FIG. 2.—SKETCH SHOWING REFLECTION OF FLOW OF STEAM FROM FIXED TO MOVING AND MOVING TO FIXED VANES.

The Parsons type of turbine differs radically from the De Laval. In both there are, of course, no reciprocating parts or even rotating pistons or oscillating cylinders as there in many inventions properly termed "rotary engines," but sometimes misnamed "steam turbines." In the Parsons turbine the steam is admitted at full boiler pressure into an annular chamber surrounding the shaft from which it flows in a direction parallel with the shaft through a series of rings of vanes or guide blades, gradually expanding from ring to ring until it reaches a large chamber, from which it passes to the condenser. The arrangement of the rings of vanes in which the steam repeatedly expands and gives up its energy by means of impact is roughly indicated by the two sketches, Figs. 1 and 2. The first shows an axial section through the machine. The containing case carries, projecting from its inner surface, rings of vanes or guide blades, between which run similar vanes mounted on the rotating spider.

If these rings were solid the arrangement would obviously resemble very closely the familiar form of thrust bearing used in large steamships, and consisting of a number of collars fixed to and rotating with the shaft interlocked between an equal number of stationary collars fixed to the casing; but in the turbine, these collars, or rings, are slotted, and steam (around their whole circumference) blows through or across them in a direction parallel with the axis of the machine. The slots formed by the vanes, which constitute the fixed collars, are inclined in such a way that as the steam passes through them its direction of flow is given a right-handed rotation around the shaft. The moving vanes are twisted in the opposite direction, so that as the steam with its right-handed rotation strikes them it rebounds and is given a left-handed rotation, with which it passes into the next succeeding ring of fixed vanes in the course of its passage axially along the drum.

The relative arrangement of the fixed and moving blades is shown by Fig. 2, those shown hatched being attached to the case, and hence stationary, and those shown only in outline being attached to the rotating spider, and hence rotating rapidly in the direction indicated by the arrow. As the steam flies between these vanes, from left to right, the stationary ones give it a right-handed rotation, throwing it into the hollows of the moving vanes, from which it bounds back, hitting the stationary vanes of the next ring, bounding again into the moving vanes, etc., giving the stationary vanes an upward thrust, as seen in the figure—that is, a left-handed torque—which they, of course, resist, and the movable vanes a downward thrust, which, being tangential to the circle of their rotation, gives power to the machine. It is quite difficult for those who have never understood this action to comprehend it, but a reperusal of the last three paragraphs will, it is hoped, make it clear. As the steam passes from left to right the vanes increase in dimensions, especially radial length, giving opportunity for expansion, so that the power given up by the steam to one ring of vanes is again made up by its expansion before reaching the next ring. This action is repeated until the steam reaches the exhaust chamber. The turbine is thus a multi-expansion engine with as many expansions as there are rings of vanes.

Referring to Fig. 1, it is obvious that all steam gives power to the turbine in this way except that which leaks over the ends of the movable vanes between these ends and the casing, or that which leaks under the ends of the fixed vanes between them and the spider. To reduce this leakage to a minimum the ends of both sets of vanes must be trimmed off with the greatest nicety to the proper diameters, so as to run as close as possible to the opposing parts without touching. There is obviously no loss by initial condensation and re-evaporation due to surfaces alternating in contact with steam under very different pressures. The steam in contact with any one set of rings remains at a constant pressure, and consequently at a uniform temperature. The only opportunity for a wasteful heat transference is by the thermal conductivity of the metal from the parts of high temperature to those of low.

The details of construction of the machines are best brought out by a description of the power plant of the Westinghouse Air Brake Company's shops. This plant is illustrated in Figs. 7 and 8, and a plan and elevation of one of the turbine sets are shown in Fig. 3. Each unit consists of a 500-h.p. turbine direct coupled to a 300-kw. two-phase alternating-current generator, the three machines being run in parallel with each other to light and furnish power for the entire works, the latter application being made by means of induction motors. The three complete steam-electrical units, having an aggregate capacity of 1500 h.p., are comfortably located on a floor space 20 by 25 feet, the bed plate of each machine measuring only 16 feet 7 inches by 4 feet 3 inches. Including two 10-h.p. engines and generators, two pairs of condensers and air pumps, and the switchboard, the plant occupies a space of only 29 by 36 feet. On account of the speed at which these units run, viz., 3600 r.p.m., the alternators do not have the usual large number of crowded poles customary in direct-coupled sets. Although they deliver 60 cycles per second, they are simple bipolar machines, with a field frame resembling closely the old Siemens type. The weight of each complete turbine and generator is 25,000 pounds, that is, 50 pounds per horsepower.

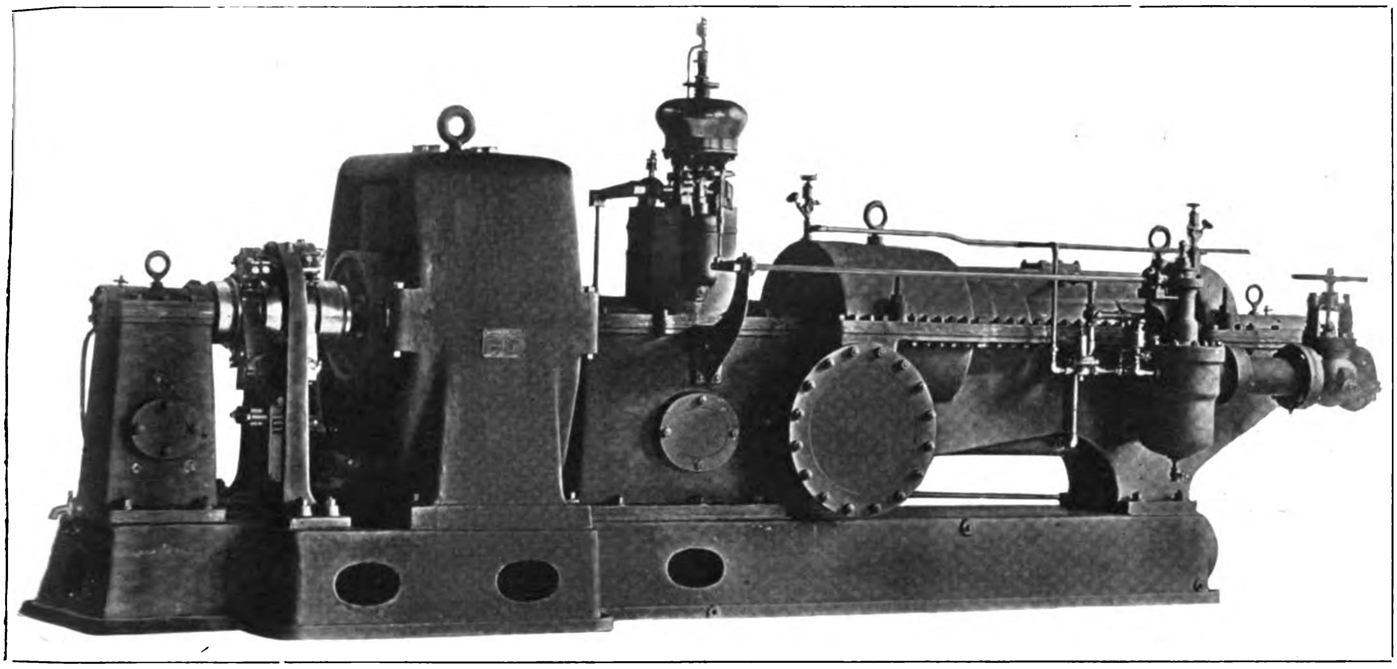


FIG. 4.—A 500-H. P. TURBINE DRIVING A BIPOLAR 60-CYCLE ALTERNATOR AT 3600 R. P. M.

The plant runs condensing, with a vacuum running up to about 28 inches, owing to which there is a very impressive fall of temperature in the short distance between the steam pipe and the exhaust, which are only 4 feet apart. The live steam at 125 pounds giving a temperature of about 350 degrees, the exhaust temperature is only a trifle over 100 degrees, and a bystander can readily bear his hand on the exhaust piping.

Referring to the illustrations and drawings of the turbine, it will be seen that the casing of that part through which the steam flows and expands between the steam inlet and exhaust outlet is enlarged in three steps, but the increase of cross-sectional area of the passages between the vanes takes place in many more smaller steps, giving a gradual expansion of the steam. The total expansion ratio, between inlet and exhaust is 96 to 1. The number of rings of vanes on the rotating spider is 58.

To counteract the end thrust on the shaft due to the axial impact of the steam on the moving blades, the rotating member of the turbine is held in equilibrium by means of three balancing discs at the left-hand end of the machine, as seen in the drawing, Fig. 3, or the right-hand end, as seen in the photograph, Fig. 4. These balancing discs are simply pistons rotating in their cylinders, with the steam pressure on one side of them. The three of them are provided to balance the end thrust in the three different sizes of casing, so that the thrust can be accurately balanced under all variations of load. The steam is admitted to the balancing discs from the corresponding sections of the expansion drums by cored passages in the rib running along the top of the casting. In this way the shaft has a very slight residual end thrust, which is taken up in an ordinary thrust bearing.

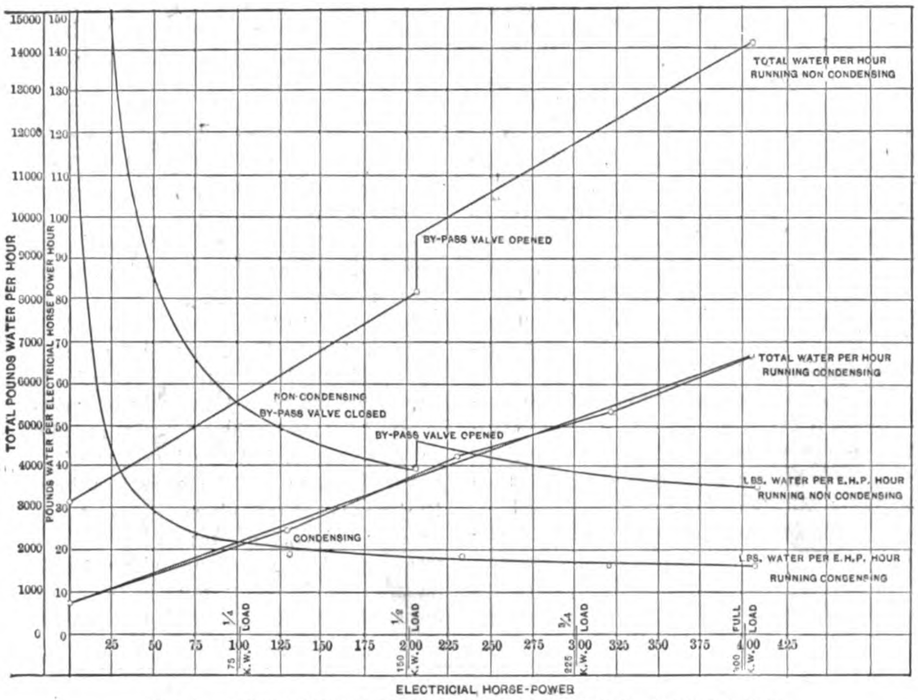


FIG. 5.—STEAM CONSUMPTION CURVES OF 500-H. P. TURBINE SETS

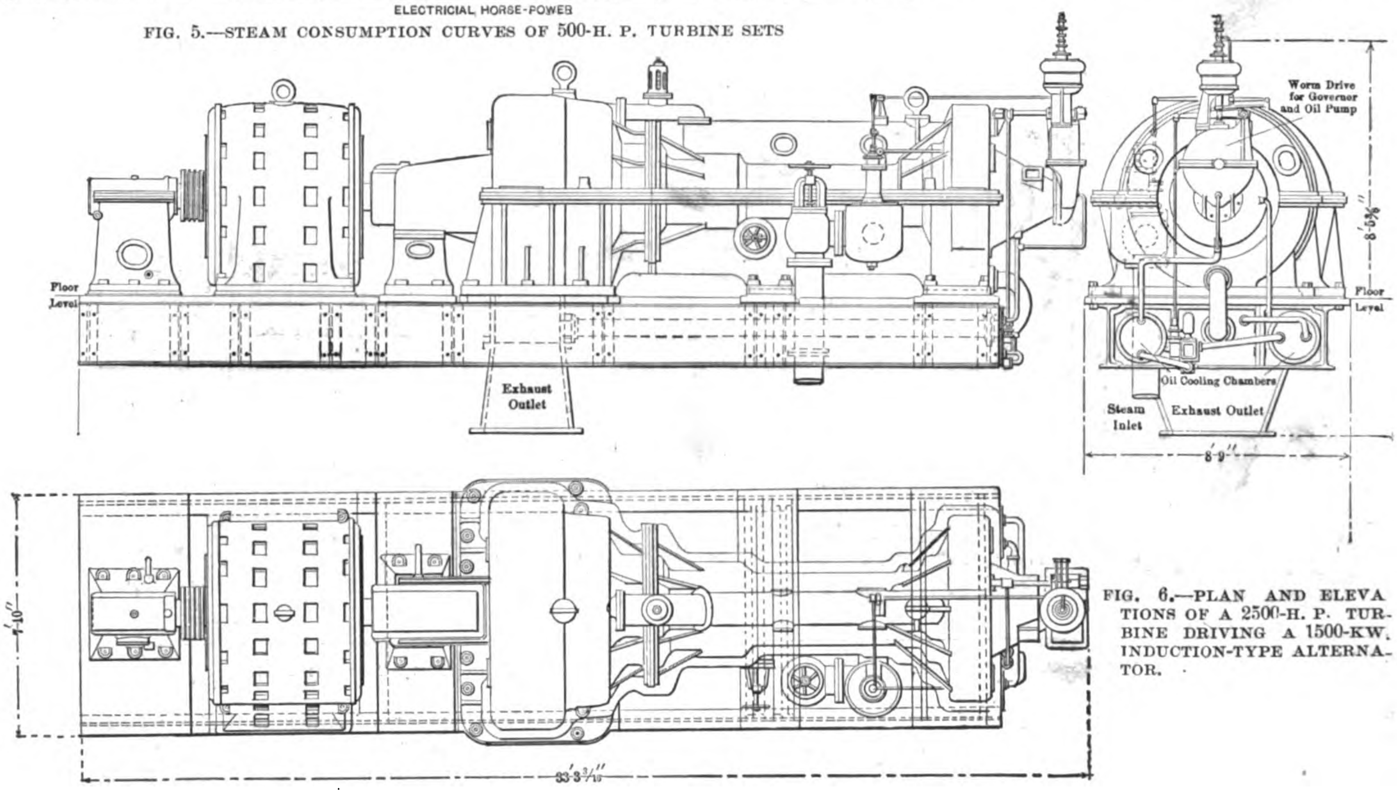


FIG. 6.—PLAN AND ELEVATIONS OF A 2500-H. P. TURBINE DRIVING A 1500-KW. INDUCTION-TYPE ALTERNATOR.

There will be noted on the drawing what is termed a "bypass valve." This, when opened, admits live steam from the engine supply to the second or intermediate section of the expansion drum. This may be used to increase the capacity of the machine when a heavy overload (up to 60 per cent.) is to be carried, or to maintain full power in case the condenser is out of operation. The increase in power is, of course, obtained at reduced efficiency.

The high speed necessitates careful balancing of the rotating parts of both turbine and generator. The balancing cannot, of course, be made absolutely perfect, so the bearings are made with a slight play to allow the center of gravity of the rotating member to settle into the center of rotation. Each bearing consists of several concentric sleeves of brass. These sleeves fit each other loosely, giving between them thin annular spaces, which fill with oil. This forms a flexible or cushion support, allowing the shaft to wobble slightly, which permits it to center itself when running. The spacing provides between the sleeves also an oil cushion, which tends to absorb any vibrations of the shaft and prevent them from being transmitted to the frame. The films of oil in the sleeves form highly frictionless bearings. All of the three bearings, including that outboard on the generator end, are made in this way.

Lubrication is, of course, in a machine of this speed most important. An oil pump is operated by a worm wheel, which in turn is driven by a worm mounted on the sleeve coupling between the turbine and the generator. This pump lifts the oil into a tank, from which it circulates down through the bearings under a slight head. From the bearings it is piped down into an oil-cooling system, where it is cooled by circulating water. The cooling is necessary on account of the close juxtaposition of the journals and live-steam passages.

The governor of the turbine is one of its most novel and interesting features. At first sight it would seem as though the only method to govern the speed of a machine of this kind—in which a part of the passages cannot be cut off and isolated from the others throughout all the numerous rings of guide blades through which the steam passes successfully—could only be accomplished by throttling. In this turbine, however, the governor acts by intermittently cutting the steam supply entirely off for a longer or shorter time, according to the amount of the load. The governor proper is of the usual flyball type and is linked to the fulcrum of a lever attached to a small piston valve. This lever is constantly oscillated at a given frequency by the worm gear mentioned above, which also drives the governor. If the governor balls move out, due to high speed, the fulcrum of the lever of the small piston valve is correspondingly moved, throwing the oscillations of the small piston valve to one end of its valve chest, while the opposite motion of the governor balls throws the oscillations toward the other end of the valve chest. The small piston valve admits steam above and below a piston, which in turn operates a large piston valve in the main steam-supply entry of the turbine. A change of the position of the oscillation of the small piston valve changes the duration of time during each oscillation when steam is admitted below the main piston valve, and the main piston is held up. At full load the main valve is open all the time and at very light

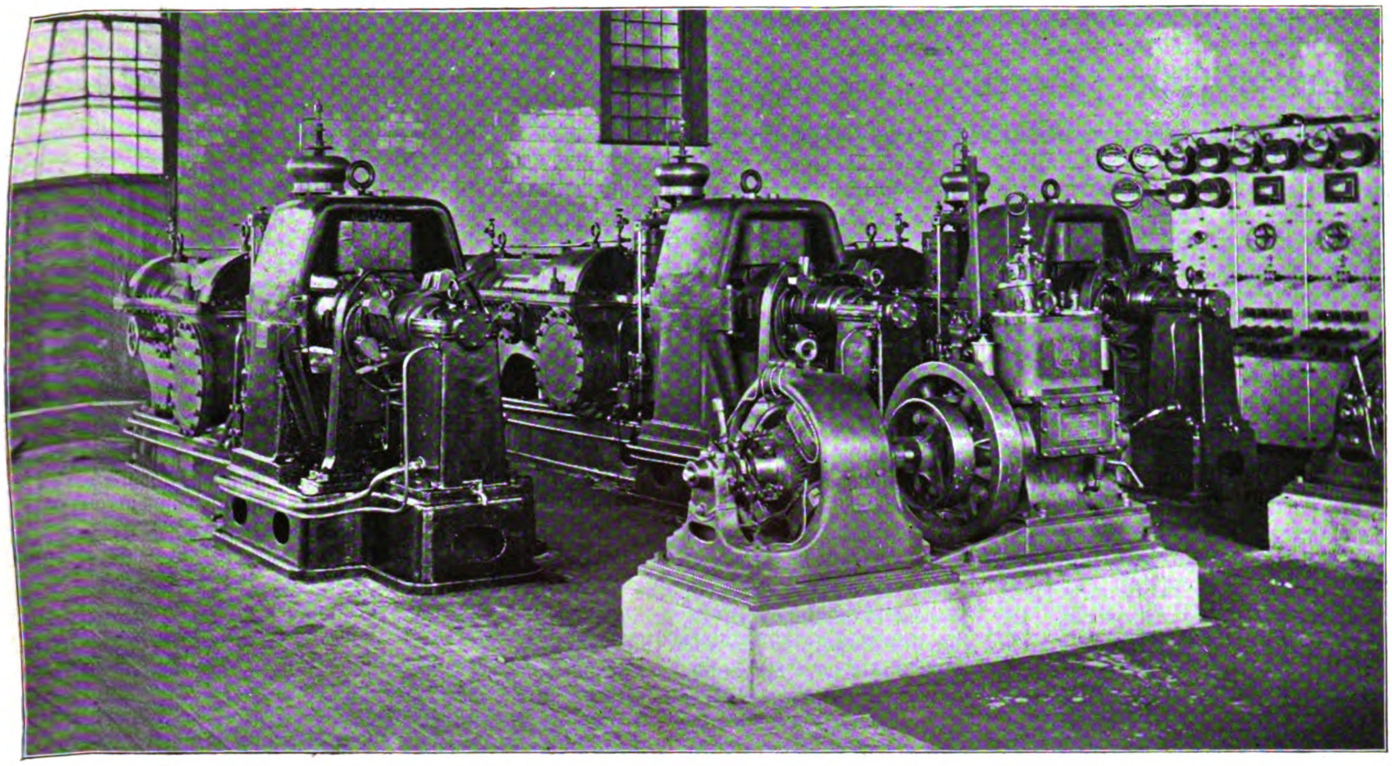


FIG. 7.—THREE 500-H.P. TURBINES AND ALTERNATORS AND A 10-H.P. EXCITER IN THE WESTINGHOUSE AIR-BRAKE WORKS.

loads it is closed most of the time. At intermediate loads it is intermittently opened and closed in time with the oscillations of the small piston valve, the duration of opening being a greater portion of the total time of one oscillation, and the duration of closing a less portion, for heavy loads than for light ones. The frequency of oscillation is 150 per minute in the 500-h.p. size.

Elaborate tests of steam consumption have been made upon these turbines, resulting in the remarkable curves shown by the diagram, Fig. 5. The long horizontal portion of the curve of steam per horse-power, showing a very slight increase of steam consumption per horse-power hour as the load is reduced, is notably different from the curve obtained with the usual reciprocating engines of the same power.

The following table shows the economy of steam at several important points:

Full	load	16.4 lbs.	steam per	electrical	h. p.	per hr.
¾	"	17.	"	"	"	"
½	"	18.2	"	"	"	"
¼	"	22.	"	"	"	"

Running light, 750 lbs, steam per hour.

An even more ambitious undertaking than the turbines above described is the 2500-h.p. machine mentioned above, which the Westinghouse Machine Company is now building for the United Electric Light & Power Company of New York City, which recently consolidated with the Edison Company and others under the control of the Consolidated Gas Company. This will be the largest unit of the kind ever as yet attempted. It will run at 1200 r.p.m. under a steam pressure of 150 pounds, and will deliver 60-cycle current from a six-pole generator rated at 1500 kw. The shaft of this machine, complete with its spider and guide vanes, weighs 28,000 pounds. The largest diameter of its moving member is six feet. A plan and elevation of this machine are shown in Fig. 6. The weight of this turbine and alternator complete will be 200,000 lbs.

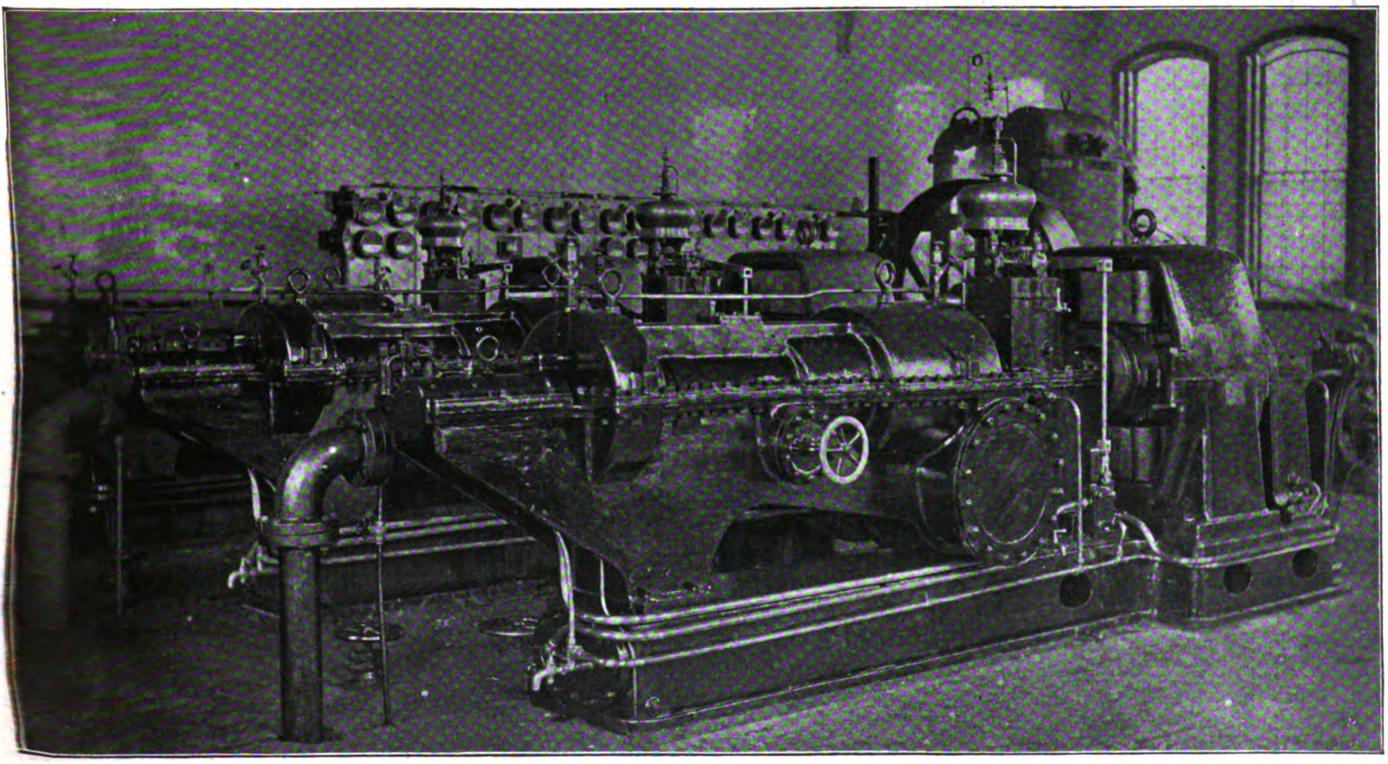


FIG 8.—ANOTHER VIEW OF THE TURBINE PLANT SHOWING CLEARLY THE THREE EXPANSION CHAMBERS AND OTHER DETAILS.

Among our Foreign Contemporaries

Electrochemical and Electrometallurgical Industries.—Electrochemistry is the youngest branch of electrical engineering, but it has made enormous progress in the past few years. There is no doubt that electrochemistry is still in its infancy, and that electrochemical methods are as a rule not yet perfected; but they have been developed more and more in recent years and have gradually replaced some of the old processes in the chemical and metallurgical industries. At the general meeting of the German Electrochemical Society of last summer, Prof. Borchers gave some very interesting statistical data, and referred to the important part which the United States takes on account of its enormous metal resources. He gives the value of the materials available in the electrochemical plants of the United States per year as $97,500,000; those of Germany $13,800,000; France $11,300,000; Transvaal $7,300,000; Switzerland $3,200,000; Austria $2,700,000; Italy $2,400,000; England $2,300,000; Sweden $2,200,000; Norway $1,800,000; which show that the United States is in this respect far ahead of all other countries taken together. For that reason a brief abstract of a series of articles by Mr. John B. C. Kershaw in recent issues of the London "Electrical Review" on the progress of electrochemistry in 1899 may be of interest. The electrolytic alkali and bleach works in operation in Europe and America will shortly number 29, while ten years ago there was not a single electrolytic alkali plant in existence. Six aluminum plants are in operation, 26,000 h. p. being available, but it is questioned whether more than one-half of this is used at present in the production of aluminum; the increase of the output during 1899 has been due to the concentration of the manufacture at the larger works; the price of aluminum has remained fairly stationary during 1899, and it is hardly probable that any material reduction in price can occur with the present method of extraction; the price at which aluminum is being sold for conductors, 29 to 30 cents per pound is said to leave little or no profit to the producers. The development of the calcium carbide industry has been so great that he fears it has been too rapid for the demand; the number of calcium carbide plants in operation or in course of erection increased during 1899 from 51 to 93; he fears that the boom will be followed by an inevitable reaction, as the competition between the larger factories must cause a decisive fall of prices. There are now nine electrolytic chlorate of potash plants in operation in America and Europe, over 33,000 h. p. being available; they could supply the whole world's demand for this chemical, but he doubts whether their present output exceeds 6000 tons, or about two-thirds of the annual production of chlorates. The number of electrolytic copper refineries is 42, the total output being estimated at 200,000 tons per year. As the aggregate copper output of the world in 1897 was 397,000 tons and 434,000 in 1898, about 50 per cent. of the world's supply of copper is now electrolytically refined. The use of solutions of hypochloride of soda prepared by electrolysis, for bleaching cellulose and cotton goods, is slowly extending in Germany, France and Russia. The progress in the utilization of ozone on a commercial basis has been slow; the numerous trials with ozonized air for the purification of potable water are being continued. The progress of the different zinc processes is briefly outlined; the Hoepfner process is coming into use, its success being due largely to the fact that chlorine is produced as a by-product at the anode, and that therefore the total cost of the electrical energy and of the operating charges can be divided between the bleaching powder, in which form this chlorine finds a ready sale, and the zinc.

Twin Carbon Arc Lamps.—In recent numbers of the "Elektrotechnischer Anzeiger" and of the London "Electrical Engineer" there is an interesting description by Mr. Mathiessen of a type of twin-arc lamp which has been recently introduced into the German market, and in which two arcs burn in series. The main advantage offered by such a lamp is that it may be connected alone across a 110-volt circuit, or in pairs across a 220-volt circuit. This advantage is very apparent where the latter pressure is used, since not every consumer can make use of four to six of the ordinary type of lamp, so that the twin arc type facilitates the general endeavor in Europe to double the pressure from 110 to 220 volts. There are some disadvantages, as the working cost is greater in the case of twin arc lamps than with single arcs, and the intensity of light given by the two arcs is not as great as that of one arc; consuming the same amount of energy, but the twin lamp is claimed to be superior to the enclosed arc type, as regards intensity of light. It is a combination of two independent regulating devices attached to a common base plate. The regulating mechanism belongs to the well-known type in which a magnet provided with a hinged armature actuates the regulating clockwork. The illustrations—Fig. 1—show the shunt-wound magnet A and the clockwork B, which latter is connected with the magneto armature M by the tongue O. The necessary opposing force to the magnet is afforded by a spiral spring N. The corresponding parts of the second regulating apparatus, so far as they are visible in the sketch, are denoted by the same letters with the addition of the number 1. The escape wheel P of the clockwork B is governed by a catch attached to the tongue G, which in turn is carried by the two-armed lever XV. and this together with the second tongue G is subjected to the common influence of the heat compensator K, which according to the temperature attained by the lamp mechanism with constant regulating tension compensates for the backward movement of the pivoted armature M by pushing back the lever arm, thereby maintaining the regulating tension of the spring approximately constant. The variation in weight of the carbon rods is rendered a negligible quantity by the method used of pivoting the clockwork, so that the regulating tension is not influenced thereby. In order to prevent the jerky movement of the clockwork, air pistons or dash pots, T, are provided. The voltage of the arcs may be regulated by adjusting the screw S, whereby the pull of the spiral spring N is controlled.

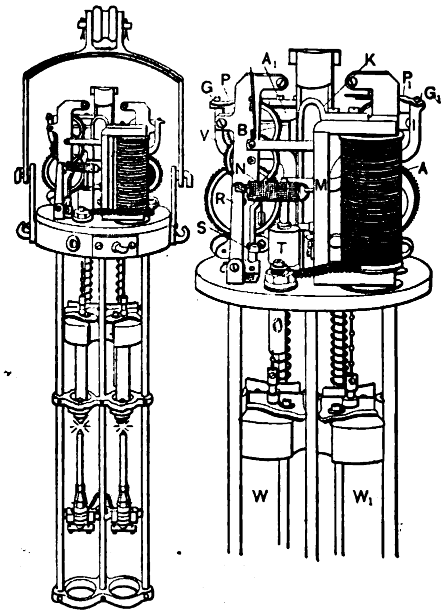


FIG. 1.—MECHANISM OF A GERMAN DOUBLE-CARBON ARC LAMP.

Continuous vs. Multiphase Power Plants in Factories.—The opinion of an English writer on the relative merits of the two systems is given in a recent article in the London "Electrical Review," which the author thought best to write anonymously. He admits that his remarks apply to the multiphase motors made in his country and not to those made in America or on the Continent, where he thinks the makers "have more up their sleeve than they will divulge"; he seems to think that American and Continental polyphase motors are better. The conclusions he arrives at must therefore not all be considered to necessarily apply also to motors made in this country. Among the advantages of multiphase machinery he cites the indisputable one that there is no commutator, and therefore the cost of maintenance of the motors is less; they are more easily started, and for the same size they are cheaper. The disadvantages are that the starting torque is not as good, and that they cannot be overloaded, for which reason the motor must be built large enough to carry the largest possible load, while a direct-current motor can stand an overload; also the use of three or more wires to each motor instead of two; it is also more difficult to take rough readings of the power, and the speed cannot be regulated to such a nicety. As will be seen, his conclusions are therefore favorable to the direct-current system.

Some Interesting Faults on Telephone Circuits.—A recent issue of the London "Electrical Review" contains an interesting anonymous article, in which the writer describes some curious faults which have occurred on telephone circuits. He quotes a case of damage by lightning which is interesting because all the wire was under ground and the ends of the wires terminated in buildings, so that the wire could not have been "struck" and the damage must have been caused by the return shock. Electric light and power circuits nearly always cause a certain amount of disturbance on telephone circuits which are worked on the single-wire system, now rapidly going out of date. When the light or power circuit is faulty, some curious troubles are experienced in the telephone exchanges or on separate circuits which are near the affected circuits. Such a case is the following: In a telephone exchange one of the operators complained that indicator No. 32 frequently fell and could not be replaced for some time, although no one was trying to call central from the distant end; this most frequently occurred at stated times in an evening, and the current would sometimes be on the line for an hour or more, then all would be right again. Shortly afterward the operator reported that the whole of the indicators, about 150, had fallen simultaneously several times. Inquiries at the house, in which telephone No. 32 was situated, revealed the fact that there was a leak to earth of 10 amperes when the lights in the billiard room were turned on. The nearest telephone wires were 40 or 50 yards from the billiard room, and these were carefully insulated. The cause of the trouble was that the telephone line was a single-wire circuit with an earth return, and the exchange was near the generating station; the current leaking to earth from the billiard room had to find its way back to the generating station; a portion of it traveled along the water pipe to which the telephone earth wire was soldered, along the earth wire, through the instrument, line wire and indicator at the exchange, to earth there, and so to the generating station. The sketch Fig. 2 shows the path of the current. There must have been an earth in the generating station or near it. The cause of other indicators dropping at the same time as No. 32, was because one end of each of the indicator coils in the exchange was connected to the same earth wire, and their other ends through spring jacks to the various line wires. When the leak to the earth in the billiard room of house No. 32 was stopped, no more trouble was experienced.

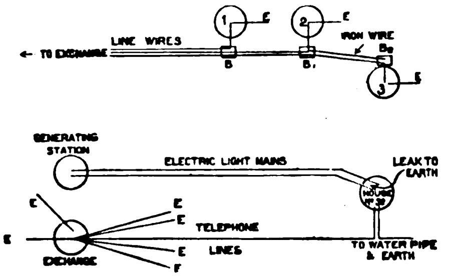


FIG. 2.—DIAGRAMS OF TELEPHONE CIRCUITS SHOWING FAULTS.

Electrodeposition of Zinc.—In our January issue we gave a notice of some experiments of Cowper-Coles, in which he tried to increase the adhesion of electrodeposited zinc to iron and steel by depositing the zinc under hydraulic pressure. In a recent number of the London "Electrician" he describes another series of experiments, in which he endeavors to reach the same result in a different way, which is quite interesting. In one set of experiments a number of specimen plates of mild steel were carefully cleaned and then coated with zinc at current densities varying from 15 to 30 amp., advancing five amp. at a time, the electrolyte containing 35 oz. of zinc sulphate per gallon and the acidity being about 0.2 oz. per gallon of free sulphuric acid. The plates were left in the zincing solution for a sufficient time to allow a calculated deposit of 1¼ oz. per square foot to be formed. The plates were then removed and subjected to special treatments, with the results that the zinc coatings turned out to be not adhesive. Another set of plates were then prepared in precisely the same way, with the exception that before galvanizing they were placed in the zincing bath and the current caused to flow in the opposite direction to that required to deposit zinc upon them, for a period of 2½ minutes. The current was then reversed and the plates treated in exactly the same way as the other set, but with the desired result that all the zinc deposits were found to be adhesive. As far as the general appearance of the deposits is concerned, there was very little difference between them. He also describes experiments with neutral solutions, from which smoother and more even deposits are obtained. He found that the cause of the stripping of zinc deposited from neutral solutions is probably due to the formation of a film of oxide on the iron plate when it is first immersed in the electrolyte. The iron and zinc not being in metallic contact, are easily separated. He concludes that the best deposits of zinc could probably be obtained by using neutral zincing solutions, and, after placing the cathode in the bath, momentarily reversing the current, so as to remove the film of oxide formed and thus secure an adherent deposit.

Accumulator Tests.—In recent issues of "L'Industrie Electrique" and "L'Electricien" there is a long preliminary official report, signed by Prof. E. Hospitalier, on the long competitive accumulator tests made in Paris under the direction of the Automobile Club of France. The conditions of the tests may be summed up briefly as follows: Each battery must not weigh more than 242 lbs. without the containing box, and must give 120 amp. hours when discharged at a constant rate of 24 amp. during 5 hours, during which the voltage must not drop below 8.5 volts for the battery; the number of cells in a battery was eight to the maker. The tests took place six times a week. On five days the discharge was rather irregular in order to approximate the conditions of automobile work. In the diagram Fig. 3, which, though published before, may be of interest again in connection with the results—the abscissas give the time in minutes, the ordinates the current taken from the batteries in amperes during half an hour. This was repeated 10 times, so that the whole discharge on a day lasted five hours and corresponded to 120 amp. hours. Arrangements were also made to subject the batteries to mechanical shocks on these five days, but owing to defects in the jolting apparatus, the shocks were only given to the accumulators during a part of the tests. Each sixth day the batteries were discharged at a constant rate of 24 amp. for five hours; whenever the voltage of the group fell below 8.5 volts, the battery was taken out of the circuit; when it was taken out of circuit four times on this account, it was definitely disqualified. The recharging of the batteries took place

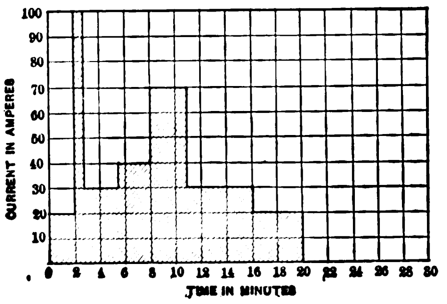


FIG 3. —LOAD CURVES ON BATTERIES.

	Tudor.	Pope.	Blot—Fulmen.	Pescetto.	Phenix.	Fulmer.	Pollock.	Metals.
Weight without containing box in lbs.	237	220	216	234	203	149	242	210
Volume in cubic feet	2.23	3.09	2.07	3.12	2.03	1.38	2.68	1.67
Number of real discharges	135	135	132	128	102	98	77	71
Total energy input in kw. hours per lb. of weight without box	0.95	1.00	0.89	0.98	0.89	1.04	0.55	0.85
Total energy output in discharges in kw. hours per lb. of weight without box	0.57	0.71	0.61	0.56	0.59	0.69	0.33	0.36
Average efficiency	60	70	68	57	66	66	56.5	56

in eight hours as a maximum, with a current diminishing from 30 amp. at the start to 15 amp. at the end. During the intervals of rest the manufacturers were allowed to examine their batteries to adjust the density of the electrolyte and to clean the cells, but not to alter any plate or to add anything. There were 127 discharges at irregular rates and 26 at a constant rate. Eighteen batteries were entered in the tests. Some were from the start unable to stand the conditions of the tests, and the committee decided to report only on the eight which survived at least 60 complete discharges before failure. In the table given above, the more important results are reproduced. The Pescetto accumulator is Italian, the Pope accumulator, which is of the Sherrin type, is English; the others are made in France; the one entitled "Metals" is made by the so-called Metals Company in Paris, which corresponds to the company making the Chloride accumulator in this country. The weight and behavior of these eight batteries are extracted from the large table given in Hospitalier's report, the French units of length and weight being converted into English. They are rearranged here in the order of the number of discharges.

Field Switch for High-Voltage Shunt Motors.—One rather serious objection to the use of shunt wound motors on circuits of 250 and especially 500 volts, is the fact that the large number of windings of fine wire on the field gives rise to a very vicious spark on opening its circuit, which not only tends to injure the switch but is apt to jump across air spaces. The voltage of that spark exists not only at the switch where the spark is produced, but of course also at the ends of the magnet coils, and it is therefore apt to pierce the insulation of those coils even though it may have been quite perfect. A burning out of the field coils in a shunt motor is apt to be followed by a burning out of the armature, for unless the field is excited there will be very little counter e. m. f. delivered in the armature which will therefore take an abnormally large current. It is therefore very important to prevent the dangers arising from that spark. Opening the circuit rapidly, which would seem at first sight to be the natural thing to do to destroy the spark quickly, is the very worst thing to do in this case, for the quicker the circuit is broken the higher will be the induced voltage of the spark; it would be better to break the circuit slowly between carbons, so as to give the induced current a chance to die out slowly, in which case the voltage will not reach such a high value. Another way used in practice is to shunt the field with some resistance like incandescent lamps for instance, a device used in elevator service; but this means that either the lamps must be left burning as long as the field current is on, or that they must be switched into circuit whenever the field curent is broken, which complicates the switch; moreover incandescent lamps are very apt to fail and the result of such a failure might be very serious. By far the best way to prevent the spark is to connect the field terminals permanently with the brushes, therefore never opening the field circuit itself, the switch being placed in the main line, and the field and armature being always in parallel; this gives the induced current of the dying field a path through the armature, which being practically a short circuit, gives the field a chance to die out slowly, therefore avoiding the induction of the high voltage. This arrangement is used in practice in this country, but it has the objection that as the starting box resistances are cut out of the armature circuit, they are necessarily put in series with the field, thereby weakening the field as the armature comes up to speed. To avoid this latter objection, which in some cases is a serious one, the very ingenious device shown in Fig. 4 was suggested by Menges and was described in several of our foreign contemporaries. It will be seen that by the simple addition of the segment a and the connection of it to the first contact block b, the starting resistances are short circuited when they are cut out of the armature circuit, and they are therefore not switched into the field circuit. This segment a is the only additional complication of the switch. If a circuit containing a self-induction and a non-inductive resistance in parallel is broken, it can be shown theoretically that the maximum possible difference of potential induced at the terminals of the inductive branch on the rupture of the circuit, is equal to the original voltage of the circuit multiplied by the ratio of the resistance of the branch without self-induction, to the resistance of the one with self-induction; if the former is low as compared with the latter, this maximum voltage will be only a fraction of the line voltage. In the present case the armature circuit is not entirely inductionless, but it is nearly so as compared with the field circuit.

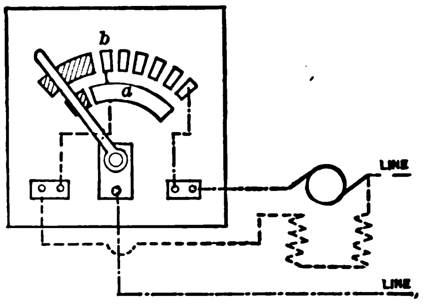


FIG. 4.--FIELD CONTACT ON MOTOR STARTER.

An Interesting Departure in Synchronous Converters.— A very ingenious and apparently new departure in converters for transforming three-phase into continuous current, is described by Mr. Herrmann in a recent issue of the "Elektrotechnische Zeitschrift," and if it does all that it appears to be able to do, it seems to be quite an important departure. The essential principal is that the field is mechanically revolved in the opposite direction to that of the rotary field produced by the alternating current, and therefore the field itself is fixed in space provided the two rotations are exactly synchronous; continuous current can therefore be taken off from the armature; moreover this may be done, as will be seen, by merely revolving the brushes, the rest of the machine being stationary, and as this requires but little power, the arrangement approaches more nearly a stationary transformer. The ordinary converter of this kind is mechanically quite similar to a direct current dynamo, except the field poles act only to produce synchronous rotation of the armature and not to produce continuous current; in a converter therefore the armature might be driven by any synchronous motor of the same number of poles, the field of the converter then serving merely the purpose of closing the magnetic circuit, and need therefore not be excited; in fact the field may be a simple solid ring without any poles. An important difference between this and the ordinary converter is that the current always lags behind the e.m.f. and this lag cannot be reduced to zero, like in the ordinary converter, by varying the exciting current; as there is no exciting current this lag varies with the magnetic reluctance, which is rather large owing to the air gap. This, however, he overcomes by the ingenious arrangement of not having any air gap at all, which is accomplished by having the field and armature made in one solid piece in the form of a ring of laminated iron. The winding which produces the rotary field, may be either a drum or a ring winding and is passed through holes, as shown in Fig. 5, which are about midway between the outside and the inside surface of the cylindrical ring; if it is a ring winding, the wires are wound back either over the outside or the inside surface. The connections to slide rings and commutator are the same as with an ordinary converter. The rotary field revolves in this ring, and if, therefore, the ring is driven by a synchronous motor having the same number of poles, and in the opposite direction to that of the rotating field, it is evident that the field is fixed in space just as it would be in a continuous current dynamo, and therefore continuous currents can be led off from the commutator. From this it

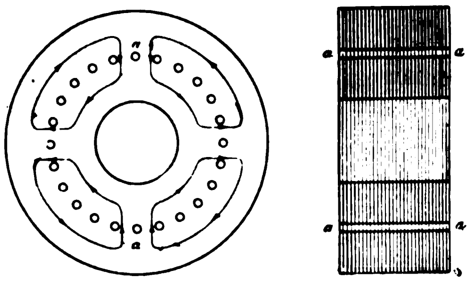


FIG. 5.--END ELEVATION AND SECTION OF MAGNETIC CIRCUIT OF CONVERTER WITHOUT MOVING IRON OR WIRE.

also follows that the ring may be kept stationary if the brushes are made to revolve instead, always, of course, by means of a synchronous motor. The illustration shows the arrangement diagramatically, the arrows showing the lines of force for a four-pole motor. A still further modification enables the step-down transformer to be avoided when a high pressure alternating current is to be converted into continuous current at low pressure. In that case there are two windings in this ring, one with a large number of turns for the alternating current and the other with a small number for the continuous current. In that case even the transformer for supplying the small synchronous motor may be avoided, as an alternating current of low tension may be taken from the low tension winding, to drive this motor. Moreover, with the same machine, high tension three-phase current may be transformed into low tension three-phase for motor driving, single phase for lighting or continuous currents.

NOTES.

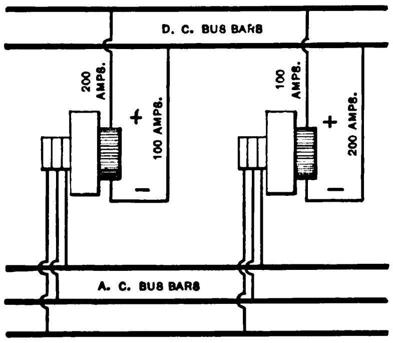
Alternating-Current Arc Lighting.—The article published in the last issue of American Electrician, on page 79, as a part of a paper presented by Mr. R. Fleming before the winter meeting of the Northwestern Electrical Association, should have been credited to Mr. E. P. Warner, who presented the paper before the Chicago Electrical Association.

The Convention Headquarters of the National Electric Light Association.—Mr. Geo. F. Porter, Secretary of the Association, announces that the headquarters of the twenty-third convention, to be held in Chicago May 22,23 and 24, will be at the Auditorium Hotel. The rates are $3.50 to $5 per day on the American plan, and $2 to $4 per day for each person on the European plan.

The Destruction of the Home of Prof. Morse.—One of the historic structures of New York City, rendered notable by the fact that it was for many years the residence of Prof. S. F. D. Morse and that he died there, will soon be destroyed to make room for a modern office building. The house was a fine brown stone mansion located at 7 W. 27th Street. It is proposed that the new structure bear an appropriate tablet.

Hydraulic Power Storage.—A rather unusual method of storing power during the hours of light load, for use at the time of maximum demand in connection with hydraulic systems, is that of the Lynmouth plant, as described in the London "Electrical Engineer." During the day time the turbines, working under a normal head of about 88 feet, drive pumps which raise water to a reservoir 760 feet above the station. At times of heavy load this water is again used in high pressure jet wheels to reinforce the power obtained from the low-head system.

A Difficulty with Parallel-Connected Rotary Converters.—When rotary converters are operated electrically in parallel with each other on both their direct-current and alternating-current ends, the a.c. supply for two or more machines being derived from one set of bus bars or step-down transformer secondaries, there is likely to arise a peculiar division of the currents that upsets commutation, renders ammeter readings valueless and is at first sight difficult to account for. This is due to the tendency of direct current to flow through the electrical connections between the two armatures via the collector rings and a.c. bus bars. If the wave form of the counter e.m.f. in the two machines differs somewhat, due to a difference between the field distortions, between the lead given the brushes of one machine and those of the other, or between the angle of lead given the positive brushes as compared with the negative brushes of the same machine, parasytic direct currents will be exchanged between the armature windings over the alternating conductors. This will give the astonishing result of a greater current coming out of the positive brushes of one machine than goes in at the negative brushes of the same machine. In this case the other machine, of course, has a greater current entering through its negative brushes than issues from the positive brushes, since the positive current leaving the two machines must be equal to the negative current entering them. For instance, referring to the accompanying diagram, the left-hand machine may be giving out 200 amperes from its positive terminal and only taking in 100 through its negative terminal, the right-hand machine in this case taking in 100 more amperes than it gives out, the alternating-current conductors between the two carrying a direct current of 100 amperes superposed upon the alternating currents of supply. The effect upon d.c. ammeter and wattmeter accuracy, commutation, etc., can readily be imagined. On this account it is becoming customary to provide for each rotary in a sub-station a separate group of step-down transformers with no cross connections between the low-tension alternating leads running from the transformers to the rotaries. One single group of transformers can be, and frequently is, used to supply two rotaries without this trouble, by winding two or more low-tension coils, one for each rotary, in each transformer and connecting these in electrically separate deltas.



An Examination for the Registration of Electricians.—In the State of Minnesota a State Board of Electricity has been appointed for registering and licensing electrical workmen. The board recently made its first report to the Governor covering six months' work. During this time it has registered 514 electricians by virtue of their standing in the trade and 23 by examination. The Board has given Masters' certificates to 30 and journeymen's to 219 and specials to 288, the last being to men working in the trade, but unable to pass the examinations.

A Large Gift to a Street Railway President.—On February 14 President Herbert H. Vreeland of the Metropolitan Street Railway Company, New York, was presented with a "valentine" of $100,000 by members of the Whitney syndicate as individuals, as an indication of their appreciation of Mr. Vreeland's management of the syndicate's interests in street railway and other properties. This munificent present to Mr. Vreeland, though perhaps the largest, is by no means the only one which he has received during his connection with the syndicate. As a recognition of Mr. Vreeland's special services in carrying out its electrical construction work, the Directors of the Metropolitan Company voted to him some time ago a substantial cash present, stating at the same time that no one whom they could have gotten in from the outside to do this work could have accomplished the results with anywhere near equal satisfaction and economy.

Electrical Illumination and Spectacular Effects at the Pan-American Exposition.—Elaborate plans have been made for the decorative illumination of the grounds of the Pan-American Exposition to be held in Buffalo next year. The leading display feature of the Exposition will be what is termed the "court of fountains," some 1700 feet long. This court will be lighted by something over 100,000 incandescent lamps of 8 and 16 c.p. No arc lamps whatever will be used for its illumination. The idea is to obtain a highly diffused illumination with no intense points of brilliancy to render the rest of the field of view dark by contrast. The same effect was tried at the Trans-Mississippi Exposition at Omaha in the summer of 1898, and there proved highly satisfactory. At the north end of the court of fountains will be what is termed the "electrical tower," some 300 feet in height. In front, and facing the court, will be a niche 70 feet high and 30 feet wide. In this niche a large jet of water will be broken up by mechanical means. The jet will be illuminated from behind its orifice by powerful arc lights, the effect of which will appear in many colors at the breakage points of the stream of water. Designs are being prepared for electric fountains to be used in the interior courts of several buildings, and a quaint variety of electrical effects will be used in other decorations.

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Low-Tension Alternating Current Central Stations.

It has often been proposed to equip isolated plants with alternating-current generators delivering a low voltage suitable for use directly in lamps without the intermediation of transformers. This proposal is rarely followed owing to the fact that isolated plants as a rule use motors, which are more satisfactory when of the direct-current type, and the alternating system has no advantages to compensate for this disadvantage.

There will be found on another page a description by Mr. W. N. Zurfluh of an alternating-current central station with a 220-volt two-wire distribution system, the 220 volts being generated directly in the alternator. In this simple case the alternating current appears to possess no advantage over direct current—unless it be the comparative simplicity of the generator, which is outweighed by the need of an exciter. There are, however, conditions in which an a. c. 220-volt supply possesses considerable advantage. In case the greater part of the load is within economical reach of the station at 220 volts while a small part is at greater distances the low voltage can be distributed directly from the station without transformers and the more distant loads can be carried by a step-up station transformer.

For the lamps of high candle power used in street lighting 220 volts is not an unsuitable pressure, but for the 16-c. p. lamps that would be used in private lighting from such a plant it increases considerably the consumption of power over and above what would be used if 110 volts could be delivered to the consumers' premises. With alternating current a neutral can be established with ease at any point on the system without running a third wire from the station. This can be done by means of a single-winding transformer, commonly called by some an auto-transformer and by others a compensator. A small transformer of this kind will balance a considerable load, because it will balance a load difference of twice its transforming capacity. For instance, a ten-light transformer will lift ten lights off from the heavily loaded side of the system and add them to the lightly loaded side. It will thus equalize a difference of twenty lights. This is ample in most cases for a local distribution with 100 lights connected. A two-wire distribution system, feeding street lights direct, and with three-wire local house lighting, would be a good combination in many cases.

The Expiration of the Three-Wire Patent.

On the 20th of this month patent No. 274,920, issued on March 20th, 1883, to Thos. A. Edison, and now owned by the General Electric Company, expires by limitation. This is the fundamental patent on three, five or multi-wire systems with any number of conductors, and as a patent has been generally respected throughout its life until the last few months. It was strongly drawn the wording showing on the part of the inventor an almost prophetic comprehension of the conditions which would exist during the life of the patent, and the drawings showing several modified arrangements for balancing which have since been either used or proposed. Among these are storage batteries and the use of a third brush on a commutator delivering from its positive and negative ends the full voltage between the outer conductors. The patent claims strongly the use of what is termed a compensating conductor or conductors, and now generally known as a neutral. At the expiration of this patent three, four or five-wire systems, with almost any means of obtaining a balance, will be open to public use.

Careless Lamp Renewals.

For years the cry of every one interested selfishly or unselfishly in incandescent electric lighting has been "renew your lamps," a piece of advice that most small central stations would do well to heed to a greater extent than they do even yet. That the advice has been thoroughly followed in some instances at least is indicated by an article on another page written by Mr. L. C. Reed, describing the proper means to prevent too careless a destruction of supposedly dim lamps.

An instrumental measurement of candle power is obviously the only proper basis for a decision as to whether a lamp ought to be retained or destroyed. With a properly equipped photometer having particularly a receptable which permits of the instantaneous insertion or removal of the lamps, the photometric measurement of a large number of lamps can be carried out with great speed, and consequently the cost is practically negligible compared with the benefits obtained.

A Prospective Revolution in Steam Engineering for Electrical Purposes.

It is of interest to those who think that "electricity is still in its infancy" to note that more revolutionary changes are threatened in steam than in electric engineering. In the electrical equipment of a traction system there is no alternative but to use 500-volt direct current, recourse being made under certain well defined conditions to polyphase distribution. In the electrical equipment of central stations the proper cases in which direct currents should be used in place of alternating currents, or a combination of both, can be foretold, so that a reasonable permanence of investment can be expected. But in the steam equipment, although steam engineering is a much older art, the proper type of engine—high speed or low speed, vertical or horizontal, compound or triple expansion—is much in doubt, and the profitable life of any steam engine is threatened by the superior claims of rival prime movers, such as the gas engine and the steam turbine. The latter machine has, during the last few years, been developed on two different lines, respectively known from the names of the inventors of many of their developments as the De Laval and Parsons type. Both of these types are now being actively perfected in this country and the results of several years' work of one are given on other pages, and are so promising that engineers of large electrical undertakings, involving engine equipments costing hundreds of thousands of dollars, may well hesitate before contracting for reciprocating engines.

The Parsons and the De Laval Steam Turbines.

A brief comparison of the action of the two types of steam turbines may be of interest to those whose ideas are hazy on this subject. In both, the translation of energy is accomplished by allowing the steam to expand, in a sense freely—that is not repressed by a yielding piston—the work done by expansion resulting first in imparting velocity to the mass of the steam itself. The kinetic energy of motion of the fluid is then transformed into mechanical power on the shaft by allowing the steam to project itself upon blades, vanes or buckets of a moving wheel and rebound therefrom, just as water gives power to the buckets of a Pelton impulse wheel. As in water wheels, the linear velocity of the vanes or buckets must be half that of the fluid projected upon them in order to obtain the highest efficiency. This explains the great inherent difficulty in the attainment of economy with the steam turbine which is the fact that the weight of a cubic foot of steam is so slight compared with the amount of energy which its expansion from boiler pressure to vacuum gives forth that its velocity is something tremendous.

In the De Laval type this expansion is all made in one step in a long flaring nozzle from which the steam issues with a velocity of something like 100,000 ft. per minute, more or less according to the number of expansions. This is so high that it is impossible to run any structure of the most perfect steel with a rim velocity sufficient for the best economy, and wheels of any reasonable diameter must have an angular velocity so high—10,000 r. p. m. or more—that gearing must be used to reduce it to a suitable velocity for any type of electrical generator, except possibly a unipolar machine. Gearing is, of course, most undesirable at this high speed. Multiple expansion and a corresponding reduction of velocity can, of course, be obtained by making of the enclosure around the first wheel a sort of intermediate receiver from which steam discharges into the expanding nozzle or nozzles of a second turbine which in turn can discharge into a succession of others to as great a number as is desirable.

In the Parsons type of turbine, on the contrary, the expansion is carried on, not in nozzles, but in the passages themselves between the blades of the runners and of the guide shutes between them (there being many through which the steam passes in succession). Each runner discharges or exhausts into the guide chutes of a new runner with passages of a larger cross section, the whole set of runners and guide chutes being mounted so that the steam has a combined axial and radial flow through the series of fixed and moving vanes, which are enclosed in one conoidal or stepped cone casing, thus giving a large number of multiple expansions in the one enclosure. The arrangement resembles a series of hydraulic turbines of the Jonval or axial-flow type mounted on one shaft with the runner of one discharging into the guide chutes of the next, and so on through the succession. The large number of multiple expansions which can be accomplished in a small space in this way brings the minimum speed to which the machine can be forced, down to a value suitable for direct coupling to dynamos, although the number of r. p. m. still remains much higher than those of reciprocating engines, or even of belt-driven dynamos.

Dynamos of Low and of Very High Speeds.

Since the earliest days of electrical engineering the greatest struggle of dynamo designers has been their effort to adapt the electrical machine to the low speeds necessary for direct connection to steam engines and thus eliminate the troublesome speed multiplication by means of such crude and unmechanical devices as belts or ropes. The load capacity of any electrical machine, other conditions remaining the same, is directly proportional to its speed. Hence, to obtain a minimum first cost the speed should be made as high as considerations of mechanical strength, lubrication and the driving member will admit. Any reduction of the peripheral speed entails a corresponding increase of the weight, size and first cost per kilowatt and as a rule causes also a reduction of the efficiency. The reduction of speed is most troublesome in the case of alternators, in which it causes excessive crowding of the poles and consequent elongated pole and coil shapes and magnetic leakage, and prevents the proper distribution of the armature winding, thus increasing the self induction and injuring the regulation. Thus alternators built for a small number of revolutions per minute, in order to adapt them to direct coupling, are forced to a large diameter and often to a ridiculously short axial length of core and active winding, increasing the cost and spoiling the efficiency of the machine.

The change from the speed of belted machines up to that of steam turbines has an effect just the reverse of that down to the speeds of steam engines, and this effect is very noticeable in the two turbine-driven machines described on another page. The 500-h.p. direct-coupled 60-cycle alternators are bipolar machines since they run at 3600 r.p.m. The dimensions as shown on the drawings appear almost ridiculously small compared with those of engine-driven units of corresponding powers. The ease of distribution of an armature winding in a large number of slots per pole in a machine of this kind is obvious. It is also plain that it is easy to generate very high tensions direct in such machines—if of the revolving-field type—with the necessary sizes of slots for insulating these high tensions and without reducing to too small a figure the number of slots per pole as well as without increasing the weight and cost of the machine per kilowatt to extravagant values.

DESIGNS FOR COMBINED ALTERNATING AND DIRECT-CURRENT MACHINES.

BY J. C. BROCKSMITH.

Under this heading there will be offered designs and working drawings for a type of combined alternating and direct-current machine, which, it is thought, will prove generally useful for experimental and laboratory work in alternating and direct currents, and which is applicable on most of the electric-lighting circuits found in practice.

The design contemplates working the machine in a number of different ways:

1. As a direct-current generator or motor.
2. As a single, two or three-phase generator or motor.
3. As a rotary converter, changing single, two or three-phase to direct current.
4. As an inverted converter, changing direct current to single, two or three-phase alternating.
5. As a phase transformer, changing alternating current of one phase to that of any other phase.

Some of the foregoing uses may be in operation at the same time, as, for instance, 1 and 2 combined would be a "double-current" generator. Also 3 or 4 and 5 may be in operation simultaneously.

Three sizes of this type of machine will be offered, of 1, 2 and 4 kilowatts capacity, respectively, and in all of these the same scale of voltage has been adopted, namely, 110 volts for the direct current, 80 volts for single or two-phase alternating, and 70 volts for the three-phase alternating. These voltages admit of considerable adjustment, however, by varying the field excitation or speed in case of a generator. The values given represent about the maximum which can be developed continuously.

In operating on single-phase alternating circuits it is necessary to adopt some device which will make the machine self-starting, and this has been provided in the shape of a special switch located in the base of the machine and which, at starting, temporarily changes the connections to those of a series motor which, as is well known, readily starts when alternating current is turned on. The armature is allowed to reach a speed slightly above synchronism, and the switch is then thrown over to the running position, where the machine operates as an ordinary synchronous motor.

In starting on two or three-phase circuits, the same switch is utilized to break up the field winding into a number of short sections on open circuit, thereby avoiding the high induced e.m.fs. which would otherwise be produced on turning the alternating current into the armature winding. It will be understood that where two or three-phase currents are employed the machine is self-starting without any special device, by virtue of the rotary field principle. If the starting current, with this arrangement, is found to be objectionably large, it can be avoided by starting on a reduced pressure supplied from small auto-transformers.

The general features of the design are multipolar field having a circular yoke of cast iron with laminated wrought-iron poles cast in. This type is selected because it admits of high magnetic density and short air gap, and consequently much greater output than does an all cast field, while at the same does it is only slightly more expensive or difficult to construct. An all cast-iron field of the same general design will have only a little more than half the output, and an all cast-steel field, while good magnetically, is scarcely to be considered at present owing to the difficulty in securing steel castings on short notice.

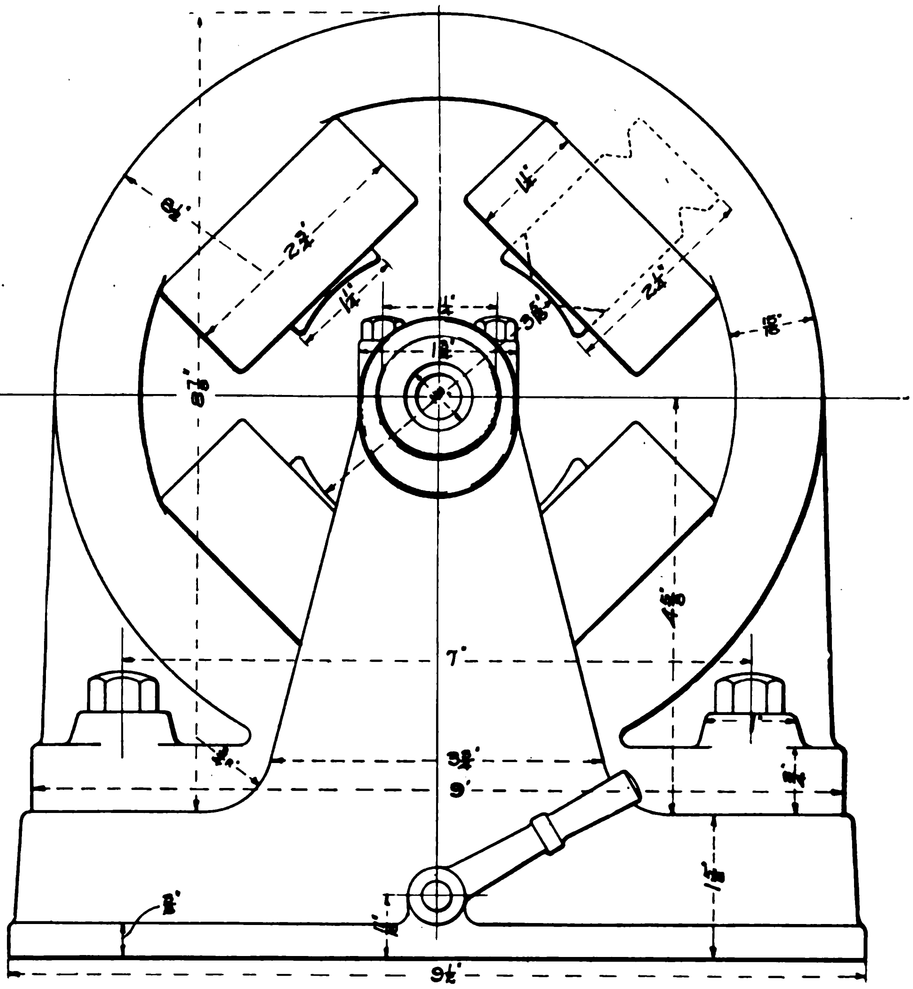


FIG. 1.—END ELEVATION OF FIELD MAGNET.

Field coils wound in two or more sections each, and provided with terminals for connection to the starting switch. This is necessary in order to obtain a sufficient reduction in the impedance by connecting the various sections in multiple at the start.

A distributed armature winding, with collector rings tapped in at appropriate intervals on the commutator for alternate-current working. A toothed armature core with deep and narrow slots, and provided with a formed-coil winding, as in direct-current practice.

The minimum number of slots and coils is determined by the number of poles and by the consideration that taps must be made for both two and three-phase working. The quotient obtained by dividing the number of coils or commutator segments by the number of poles must be divisible by two for two-phase working and by three for three-phase working, and hence by two times three for both together. Thus 24 coils and segments are appropriate for a four-pole machine, 36 for a six-pole, and so on.

Six collector rings will be required; ordinarily seven would be necessary, four for two-phase and three for the three-phase. By making one of the two-phase rings the starting point for the three-phase, one ring serves for two, and the total number may be reduced to six.

It would be possible, of course, to use but four rings, obtaining three-phase current by means of two-phase three-phase transformers, but it is preferable to add two rings and obtain all phases directly from the machine.

The hollow base plate, which is cast in one piece with the bearing pedestals, serves as a housing for the starting switch already referred to. This switch is operated by a lever on the outside, at the front or d.c. end of the machine, and has two positions 120 degrees apart, the starting and running positions respectively. In the starting position the various sections of the field winding are in parallel with each other and in series with the d.c. end of the armature.

In the running position the field sections are in series, giving the maximum resistance, and are placed across the d.c. brushes, at the same time alternating current from the single-phase mains is turned into the collector rings.

A pulley having a heavy rim for the purpose of securing a considerable fly-wheel effect will be found advantageous in adding to the smooth running of the machine, particularly when used as a rotary from the a.c. end.

A pulley of this kind will also be useful where the machine is to be used as a generator direct belted to a gas or gasoline engine. The need for a considerable amount of momentum in the running parts of a rotary is real and genuine, for without it there is a disagreeable oscillation or "pumping," which makes synchronism unstable and sometimes causes the machine to break out of step even before full load is reached.

The bearings are of the ring-oiling type, and of a form which gives good lubrication without the disadvantage of having oil thrown off outside the bearing.

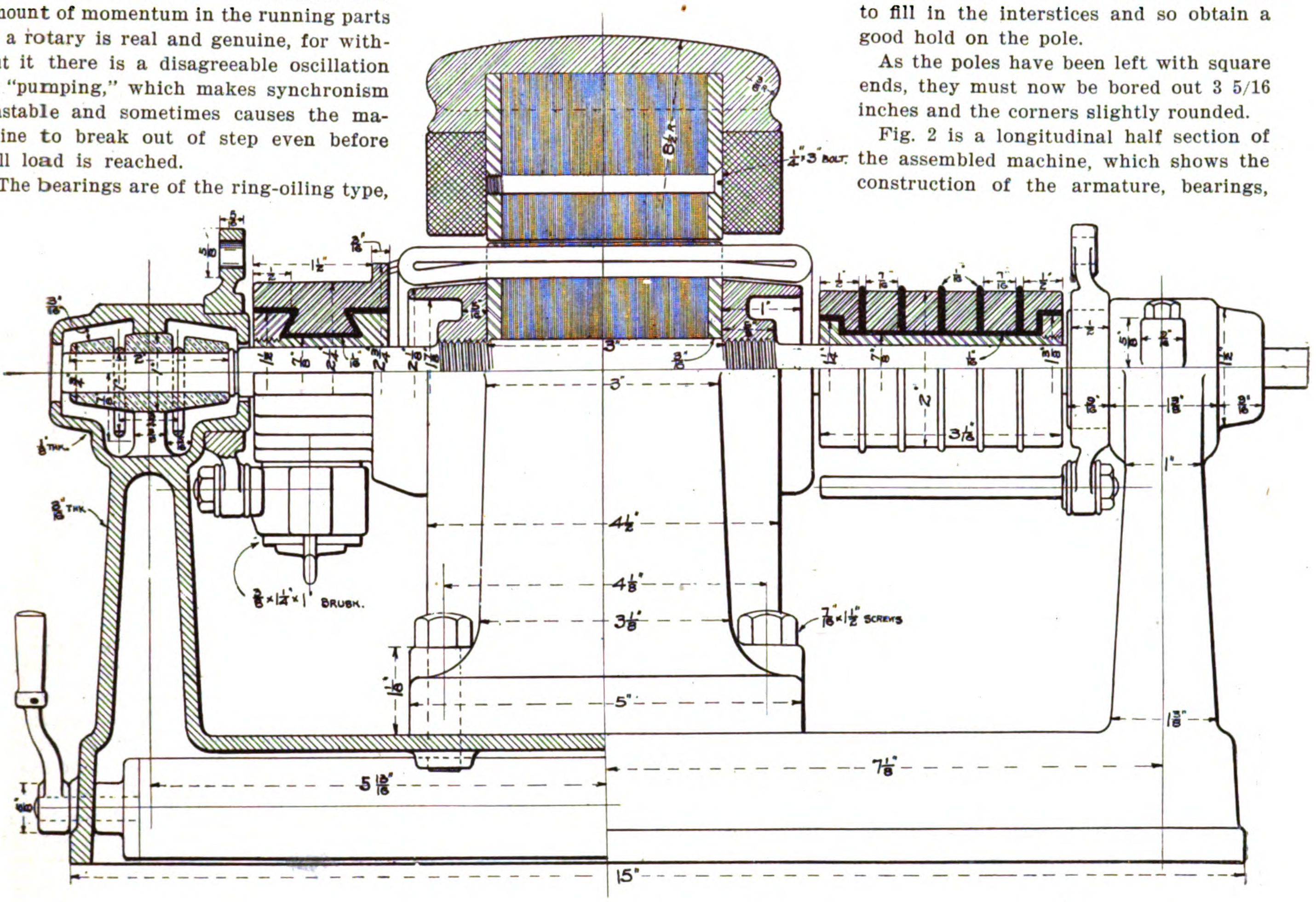


FIG. 2.—VERTICAL SECTION OF MACHINE ASSEMBLED.

The running qualities of these machines will doubtless prove quite satisfactory. There is not likely to be trouble from sparking, in spite of the fact that the armature is multiple wound, in which, ordinarily, a slight lack of symmetry in field strength would cause heating and sparking. The connections already made to the collector rings for another purpose serve also as equalizers, which permit equalizing currents to flow and thus counteract any slight inequality in the various field poles.

Armature reaction may be guarded against by clipping off the corners of every third lamination in the field poles. This will have the effect of increasing the density in the pole tips to practical saturation, thus avoiding further distortion by armature currents and giving practically a fixed point of commutation for all loads.

Heating in the armature and field windings should not prove serious, for the current densities employed are moderate, considering the size of machine. In the pole pieces, heating would ordinarily be expected, due to the short air gap and high density, but their laminated construction will entirely obviate this difficulty.

While primarily intended for use on 125-cycle circuits, modifications will be indicated enabling these machines to be used on 60-cycle circuits also. This involves either a reduction in speed of one-half, with a correspondingly reduced output and voltage, or a reduction in the number of poles to one-half, keeping the speed and output the same, but necessitating a somewhat more difficult change in connections and winding.

THE ONE-KILOWATT MACHINE.

Referring now to the one-kilowatt machine, Fig. 1 shows an end view of the field magnet and base. There are four poles cast into the yoke, which forms a separate casting and is bolted to the base plate by four 7/16-inch by 1½-inch hexagon cap screws. The poles are built up of plain rectangular strips of soft iron about No. 22 gauge, which are clamped between two heavier plates by one or more long flat-head bolts.

The pattern for the field casting should be made just as though it were for an all cast field, the laminated pole pieces being laid in the mould after the pattern has been drawn, and the iron poured in around them. The natural shrinkage of the metal on cooling will cause the poles to be tight and secure. It would give additional security, however, to notch the poles before casting in as indicated by the dotted lines. Still another plan is to leave the end plates short, and to spread the laminations apart where they enter the yoke. This will allow the iron to fill in the interstices and so obtain a good hold on the pole.

As the poles have been left with square ends, they must now be bored out 3 5/16 inches and the corners slightly rounded.

Fig. 2 is a longitudinal half section of the assembled machine, which shows the construction of the armature, bearings, commutator, and collector rings, and also the location of the starting switch in the base.

The armature core is built up of soft-iron discs about No. 27 gauge; two heavier discs of wrought iron, 3/16 inch thick, are provided at the ends as a reinforcement for the teeth, and the whole is clamped between two cast-iron flanges run up on threads cut in the shaft. These flanged pieces serve also as a support for the "straight-out" winding.

Plain round discs may be used in building the core and the slots milled out, being careful, however, to take the discs apart after milling and insulate them with paper or japanning. The keyway in the discs insures their registering when reassembled, in spite of possible slight inaccuracy in milling the slots. It is not necessary to insulate the discs from the shaft if they are fairly well insulated at all other points.

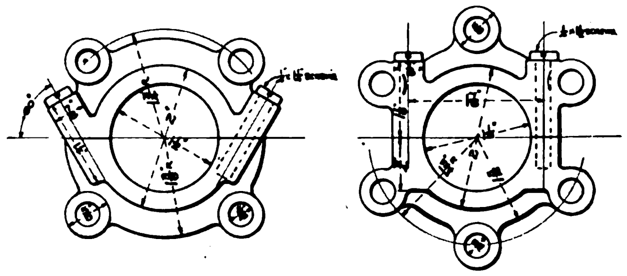


FIG. 3.—D. C. AND A. C. BRUSH-HOLDER COLLARS.

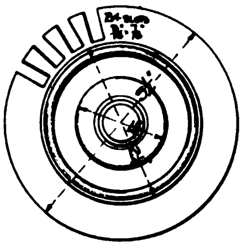


FIG. 5.—ARMATURE HEAD.

The bearings have a central rib ⅜ inch thick, which supports the brass or bronze sleeve forming the journal proper. The oil pockets at either side of the web communicate by means of a slot cored out in the web, so that the oil level may remain the same on each side. The oil rings are ⅛ inch wide and ride on the shaft through grooves turned eccentrically in the sleeve.

The commutator has a steel sleeve fitting the shaft, upon which are two flanges, one solid with the sleeve and the other threaded on it and tightened by means of a spanner wrench applied to holes drilled in its face. Both flanges are undercut at an angle of about 60 degrees, to hold the segments in place.

Probably the best way to construct the commutator is to turn up a copper casting of the required section, and then slit the cylinder into 24 segments by means of a 1/32-inch cutter, in a milling machine. The segments are then built up with 1/32-inch mica between and insulated from the sleeve by 1/16 inch of mica or other good insulation.

The collector rings are similar in construction. The two end rings are counterbored to let in the flanges of the sleeve, which, in this case, need not be undercut. The other rings are plain round and are simply slipped over the insulating sleeve, and separated from each other by 1/16-inch fiber, or equivalent insulation, which is allowed to project somewhat above the surface of the rings.

Connections to the rings are made by drilling in from the back side and soldering in short wires, No. 12 or No. 14, which should be carefully insulated where they pass through other rings by small fiber or rubber tubes. These wire leads are made only just long enough to project a short distance from the back ring and are there soldered to some thin copper strips taped and laid in the bottom of the armature slots, six of which have been cut 1/16 inch deeper than the rest to accommodate these connections. It will be the more convenient to make all these connections permanently and test them before laying on the armature coils.

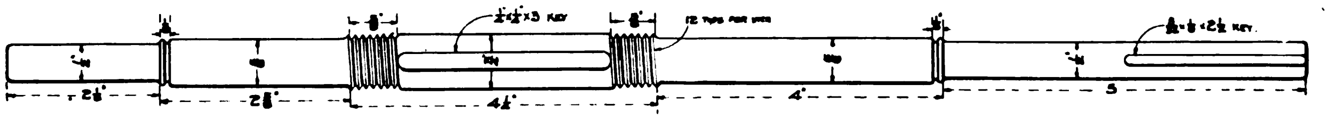


FIG. 6.—ARMATURE SHAFT.

Fig. 3 shows the brush rings for both the alternating and direct-current ends of the machine. They are made in halves, held together by screws, which will facilitate in assembling the machine. The d.c. ring has four lugs for supporting the brush holder and the a.c. ring has six, one for each of the six collector rings.

Fig. 4 shows details of the d.c. and a.c. brush holders. The d.c. holders are of simple construction, but neat in appearance, and are intended for radial graphite or carbon brushes ⅜ inch thick, 1¼ inches wide and 1 inch long. The necessary tension on the brush is supplied by an open-coil spring concealed in a hollow lug cast on the side of the holder, and acting on a small pressure foot shown separately in the drawings. By lifting the pressure foot by means of the eye at its top and turning it half around, a brush may be readily removed from or inserted into the holder.

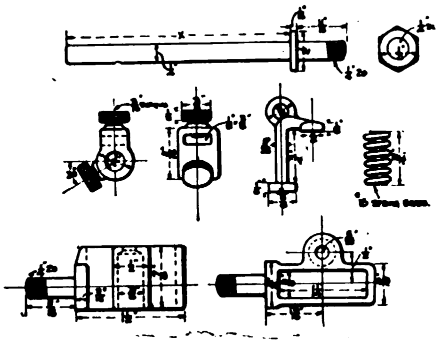


FIG. 4.—BRUSH-HOLDER DETAILS.

The a.c. brush holders are carried upon studs supported from the brush ring, and have slots ⅛ inch by ⅜ inch for copper-leaf brushes. There need not be any spring tension provided, as the natural spring of the brush will be sufficient to insure good contact. Two thumb screws are provided, one to hold the brush and the other to clamp the holder upon its stud in the desired position. The studs are of different lengths, the dimension marked X having the values 3⅛ inches, 2⅝ inches, 2⅛ inches, 1⅝ inches, 1⅛ inches and ⅝ inch for the six studs.

Quarter-inch brass rod may be used to make these from, the collars being soldered or threaded on and the ends threaded for a hexagon nut.

All brush holders and parts should be made in brass or bronze.

Fig. 5 shows an end view of the armature core and Fig. 5A a development of the armature winding. The core has 24 slots 3/16 inch wide and 7/16 inch deep. Every fourth slot is made ½ inch deep to allow space for connections to the rings. The teeth are plain straight and the armature must be banded after the coils are in place.

The armature winding is of the type known as "straight out" and is composed of form-wound coils of No. 20 double-cotton covered wire, each coil consisting of 16 turns arranged four wide and four deep. The coil is wound as a simple straight loop, and after receiving a wrapping of tape it is bent or spread until it will span one-quarter of the armature circumference.

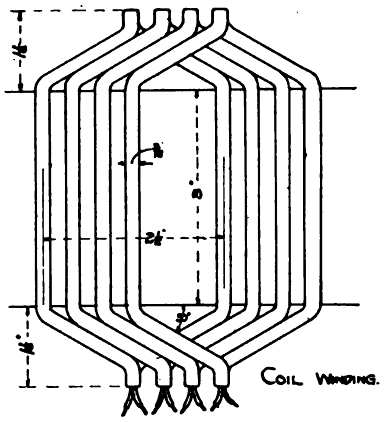


FIG. 5A.—DEVELOPMENT OF WINDING.

One side of a coil occupies the top of a slot and the other side of the same coil occupies the bottom half of a slot 90 degrees, or six slots, in advance of the first. Thus arranged, the coils interleave in a very compact manner and the space required for cross connection is reduced to a minimum.

The terminals are brought out at the apex of the coil and are connected directly to the commutator segments, the beginning of one coil and the ending of the adjacent coil connecting to the same segment. The advantage in bringing the terminals straight out to the commutator in this way is that, in addition to being more convenient, it permits the brushes to be placed opposite the poles, where they are more accessible than when placed between the poles.

Fig. 6 is a detail of the armature shaft. This is designed to be turned from a piece of ¾-inch cold-rolled steel, and for this reason the customary collar at one end has been omitted, and instead threads are cut on both ends for receiving the end plates of the core. This does away with expensive forgings and provides a shaft requiring only a minimum amount of turning. Small grooves are provided at the journals which prevent oil from creeping along the shaft and being thrown off outside the bearing. There are two keys on the shaft, one for the core punchings and the other to hold on the pulley.

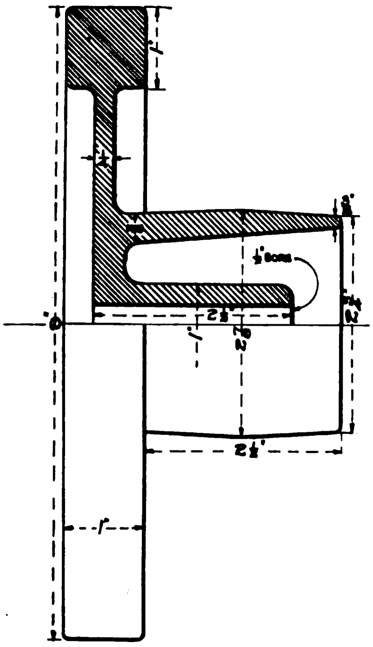
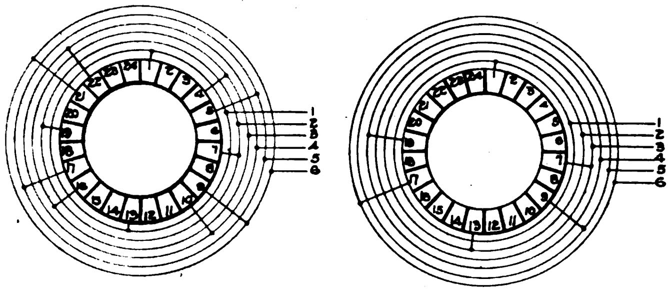


FIG. 7.—FLY-WHEEL PULLEY.

Fig. 7 shows a form of fly-wheel pulley which is recommended as conducing to smooth running, for reasons already referred to. This pulley is of cast iron and should be turned perfectly true all over and carefully balanced, as should also the armature. These rotating parts will be required to run at 3750 r.p.m. on 125 cycles, and unless precautions are taken the vibration will be excessive.



FOUR-POLE CONNECTIONS.—FIG. 8.—TWO-POLE CONNECTIONS.

Fig. 8 shows diagrams to be followed in making taps to the collector rings. The 4-pole arrangement is intended for operating on 125-cycle circuits and the two-pole for 60 cycles. These connections should be made at the back of the commutator before it is placed in position on the shaft. In the four-pole arrangement, for instance, segments No. 1 and No. 13 are connected together and to a lead marked No. 1, which goes to collector ring No. 1, and similarly for the others. Thus connected, single-phase current may be obtained from rings 1-2 or 3-4. Two-phase current from 1-2 and 3-4 and three-phase current from 1-5-6. The output and voltage with these various connections are as follows: Direct current, 10 amperes at 110 volts; single-phase alternating, 10 amperes at 80 volts; two-phase alternating, 7 amperes per phase at 80 volts; three-phase alternating, 6 amperes per phase at 70 volts.

Fig. 9 shows the arrangement of the switch cylinder and contacts for the single-phase starting device. There are 30 contact fingers, each 5/16 inch wide, fastened to a strip of fiber ¼ inch thick, which in turn is screwed to the under side of the cast-iron base of the machine. Upon a cylinder of hard wood or fiber 1¼ inches in diameter are arranged two rows of brass pieces, sunk in grooves cut on the cylinder and upon which the stationary contact fingers press.

The cylinder may be rotated through an angle of 120 degrees by means of a handle on the outside. The contacts on the cylinder are 120 degrees apart, which allows sufficient space for the first set to leave contact before the second comes into contact, this being essential to avoid short circuit.

Fig. 10 shows a diagram of connections for the starting switch, by means of which its action may be readily traced out. Numbers 1-12 represent the sectional field winding, there being four coils, each of which is wound in three sections of approximately equal resistance. There are then twelve pairs of ends which lead down into the base of the machine and are connected to the stationary contact pieces, which are represented by the upper row of small circles. The remaining three pairs of contacts connect to the d.c. brush leads, the single-phase rings and the single-phase mains respectively.

The lower rows of circles represent the contact pieces mounted on the cylinder, and these are connected, as here indicated, by means of wires laid in grooves upon the cylinder and occupying that portion of the cylinder over which the contact fingers do not pass.

To operate the machine at 110 volts direct current or 125-cycle alternating, no changes are necessary. For 60-cycle alternating, however, the number of poles is reduced one-half by reversing the terminals of any two successive field coils, and the armature winding must be changed to a bipolar one.

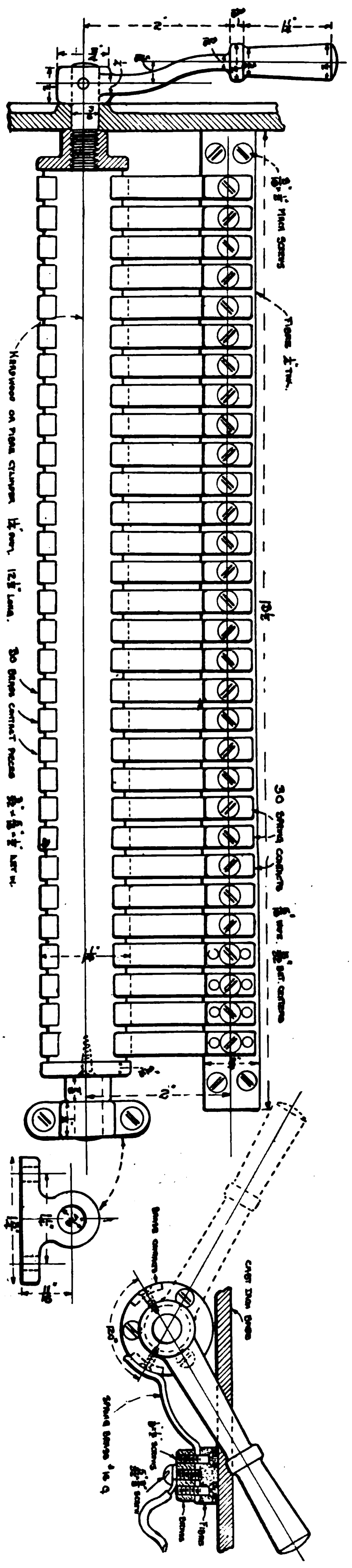


FIG. 9.—STARTING SWITCH.

Another plan is to reduce the speed one-half, thus halving the voltage and output and connecting the field coils in series multiple so that they will still take the same current as at the higher voltage. In operating the machine as a converter, if it is desired that the d.c. output be at 110 volts, the single or two-phase a.c. input must be at 80 volts. This relation of voltage is fixed and can be expressed by d.c. volts × .707 = a.c. volts, and for three-phase by d.c. volts × .612 = a.c. volts. So that if the alternating circuit is of 52 or 104 volts the machine should be supplied at the proper voltage through a transformer. An old 15-light transformer will serve for this purpose, and it should be arranged so that its secondary voltage can be varied to some extent by changing the number of secondary turns in circuit, thus giving a means of adjusting the direct-current voltage.

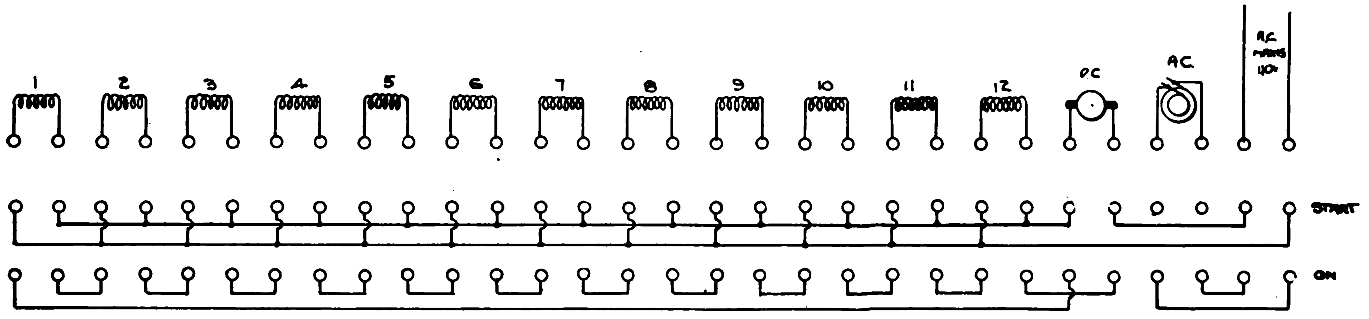


FIG. 10.—DIAGRAM OF CONNECTIONS FOR STARTING SWITCH.

The following is a brief summary of the data for winding and general dimensions, and shows the method of calculating same:

Four-pole machine, 3750 r.p.m.; armature, 3¼ inches diameter, 3 inches long; 24 slots, 3/16 inch wide, 7/16 inch deep; total number of conductors, 768; 24 coils, No. 20 wire, 4 wide, 4 deep; No. 20 has 1021 circ. mils, diameter d.c.c., .042 inch; d.c. output at 400 c.m. per ampere, 10 amperes; useful lines per pole $\dfrac{115 \times 10^8}{768 \times 62.5} =$ 240,000; total lines, 330,000.

Part.	Material.	Total lines.	Cross section.	B.	H.	L.	Amp. turns.
Armature	Wrought iron	120,000	2.25 sq. ins.	53,300	14	1.4 in.	20
2 air gaps	Air	240,000	4.5 "	53,300	16,800	.06 "	1,000
4 teeth	Wrought iron	240,000	2. "	120,000	180	.45 "	80
2 cores	Wrought iron	330,000	3.75 "	88,000	20	1.5 "	30
1 yoke	Cast iron	165,000	4, "	41,300	74	4.25 "	315
Total							1445

The table above gives a total of 1445 ampere turns or 725 ampere turns per coil; mean length, 1 turn, 11 inches.

Circ. mils shunt wire $\dfrac{11 \times 11 \times 725}{25 \times 12} =$ 290.

Use No. 25 wire, 320 c.m., .028 inch d.c.c.

1155 turns (approximate) per coil; 25 layers, 45 wide.

Wind in three sections. Bring out terminals from each section.

Resistance of shunt field =

$$\frac{4 \times 1155 \times 11 \times .97}{1000 \times 12} = 136 \text{ ohms.}$$

Normal shunt current, .63 ampere. Use a rheostat of about 50 ohms total resistance in shunt-field circuit.

Weight of wire in shunt coils =

$$\frac{4 \times 1155 \times 11 \times .97}{1000 \times 12} = 4.1 \text{ pounds.}$$

Length of wire each armature coil =

$$\frac{16 \times 13}{12} = 17.4 \text{ feet.}$$

Total of wire, armature, = 24 × 17.4 = 417 feet.

Total weight armature wire =

$$\frac{417 \times 3.09}{1000} = 1.3 \text{ pounds.}$$

Resistance of armature = $\dfrac{417 \times 10.1}{1000 \times 16} =$ .26 ohm.

Drop in armature at full load = 10.63 × .26 = 2.76 volts.

Designs for larger sizes of this type of machine will be given later.

◆

THE USE OF ALCOHOLIC SHELLAC FOR ARMATURE TROUBLE.

Gum shellac is one of the most important articles used by electricians and manufacturers of electrical apparatus, and has uses not widely known, but of great value to the artisan in the electrical field. This is especially true of its use in the repair of motor armatures and fields in street railway shops, where most things must be done in a hurry, and extra cars and armatures are not always available.

Many times the truckmen have a motor torn apart waiting for an armature, when the knowledge of the uses of alcoholic shellac in certain repairs would mean a car ready for service in short order, and resumption of the regular car schedule, which means so much to all street car companies.

Shellac has had a greater use than any other insulating solution, and in spite of the many patented compounds made in recent years, will always remain in favor. True, there are those who do not like it, and condemn its use; but on the other hand, it has many admirers who cannot be induced to use any other compound. Wood alcohol should, however, never be used to cut shellac, since it is liable to cause trouble. Grain alcohol costs but little more, and is reliable.

In winding a coil of many layers, it is necessary to heat it in some sort of an oven. Steam is sometimes used, but heat from electric heaters is probably most convenient. Let the heating be done thoroughly, or the alcohol will corrode the wire, and a short-circuit will result. One of the most satisfactory methods, and easiest applied where the facilities are at hand, is to dry out the coil by passing a sufficiently heavy current through it to heat it. The requisite temperature is about 130° Fahr. The temperature should not exceed 140° Fahr. on the outside of a thick coil and 160° for a thin one. There is danger also in using shellac too freely, as such abuse will end disastrously. Like oil, it should be used "little in the right place, at the right time." Let a wire be placed across the vessel containing the liquid, and all surplus shellac wiped off. There will thus be no waste, and a clean job will result.

A short-circuit in an armature that burns away the mica between the segments of a commutator often burns a considerable hole; and a knowledge of quick methods comes very handy at such a time. After all results of the burn have been removed and the cause of the trouble has been repaired, mix pulverized mica with alcohol shellac and fill the cavity. If it is necessary to use the armature immediately, dry the paste with a soldering iron, scrape off the surplus, and sandpaper the commutator until smooth. Should there be a flat spot on the commutator caused by the arc, making it necessary to turn the commutator, take off only enough to true it, and fill the remainder of the hole as directed above; for it is a useless expense to cut off more, since the mica and shellac mixture is thoroughly reliable.

SELECTIVE SIGNAL AND PRIVACY SWITCH FOR PARTY-LINE TELEPHONES.

BY H. S. WEBB.

In another patent than that referred to in the last issue of the American Electrician, Mr. Barrett discloses a method whereby six subscribers may be connected on the same pair of wires and the ground circuit as before, and, in addition to the selective ringing feature, he has provided means for preventing any of the six subscribers, except the one calling up central or called up by central, from cutting in on the line and overhearing the conversation.

The device for selectively signaling any one of the six subscribers is a polarized bell like that used in the preceding patent, except that it is wound and connected a little differently, and the privacy switch device is another exactly similar polarized electromagnet, the motion of whose armature opens and closes the receiver circuit and also causes a busy sign to be displayed as occasion requires. The arrangement of the two polarized electromagnets on the door of the telephone box is shown in Fig. 1 and the one for securing privacy and operating the busy signal is given more in detail in Fig. 2. The armature d (see Fig. 2), when it moves, communicates its motion by means of the rod d to f, thus causing the busy signal shutter f' to be moved behind or away from the window f² in the cover of the telephone box. The armature d has attached to it a flexible spring, d² d³, which in the normal repelled position of the armature touches the insulated screw d⁴. This spring, which is very delicate, is so adjusted that the armature will stay either in its attracted or repelled position, i.e., it will remain in the last position to which it was moved, if the current through all the coils is broken.

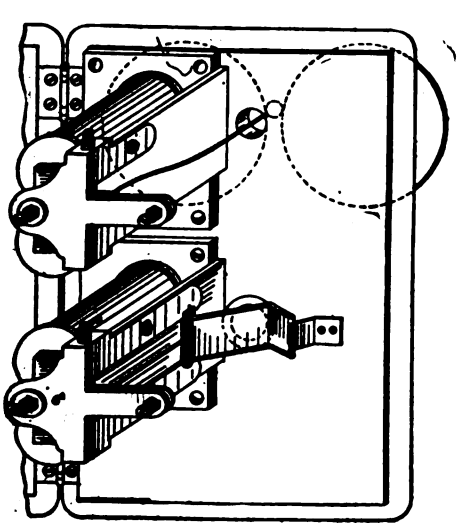


FIG. 1.

The normal position of the armature of the selective ringing device is one of attraction, and the armature will always be drawn to the cores of the magnet when there is no current in any of its coils, thus acting exactly as the similar piece of apparatus did in the preceding patent. The connections for three stations are shown in detail in Figs. 3, 4, and 5 and these figures will be used in explaining the system. In these figures h is the polarized device whose armature is normally drawn toward the poles of the magnet, and the rapid vibration of whose armature rings the bell; g is the polarized device which operates the busy signal and secures privacy by the opening or closing of the subscriber's receiver circuit at d caused by the operator at the central exchange (see Fig. 6) depressing key L or W respectively.

On each core of each polarized electromagnet is clearly shown, in Fig. 3, 4 and 5, the number of coils, the relative number of turns in each coil, direction in which each coil is wound and to what circuit each coil is connected.

To call up the central exchange the subscriber merely takes down his receiver. This causes an upwardly projecting stud attached to the hook switch (see Fig. 3) to momentarily connect the spring l⁵ with l⁶ as the switch moves upward, thus connecting line 2 with the ground. This temporary grounding of line 2 operates a differentially wound annunciator at the central exchange. This annunciator is not shown in Fig. 6, but it is connected in the circuit in the same manner as the one in Fig. 1, page 81, American Electrician for February, 1899. The continuity of the receiver circuit between lines 2 and 4 is controlled by the position of the armature d of the privacy switch. The six subscribers comprise three groups of two each, two stations in each group being similar but called up by currents of opposite polarity. Consequently, three typical arrangements of the circuits for the selective bells and the privacy switches need only be considered. These three arrangements of circuits are shown in detail in Figs. 3, 4 and 5.

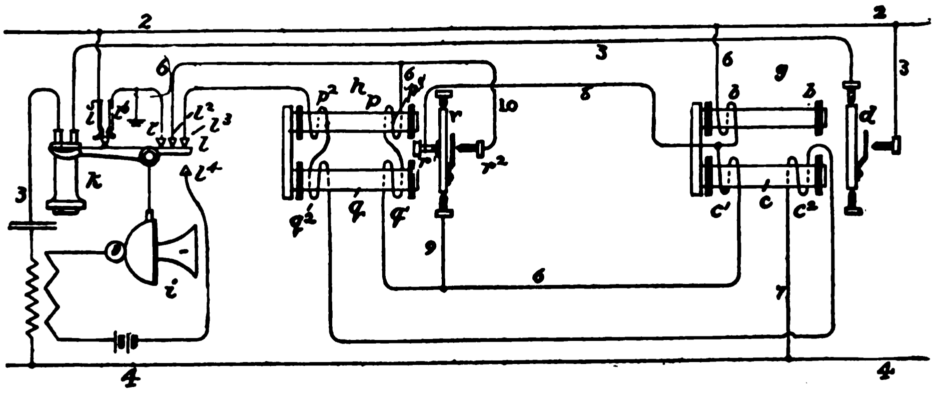


FIG. 3.

Fig. 3 shows the arrangement of apparatus and circuits for station 1, which is selectively called by a positive current over line 2, returning to the central exchange through the ground. This combination of circuits and direction of current is obtained by depressing key 1 at the central exchange. Each of the cores p and q of the polarized electromagnet h at this station has two windings, which are designated by letters p¹ p² and q¹ q², respectively. The direction of winding of p¹ and q¹ is such that when both are traversed by a current coming from line 2—i.e., a positive current in line 2—they tend to develop north polarity in both p and q and to repel the armature. The coils p² and q² are wound in opposite directions so that a current through them will magnetize their cores oppositely; thus p has south polarity and q north polarity, respectively, when a positively directed current flows through them from line 4, and vice versa when a negative current passes through them. Thus a positive current from line 2 through coils p¹ and q¹ to earth would tend to produce the north polarity in both cores p and q necessary for repelling the armature of the bell h, while current, of either polarity from line 4, through the coils p² and q² would tend to produce opposite polarities in the cores p and q. Thus one or the other of the two cores would in all cases, when current flowed through coils p² and q², hold on to the armature which has north polarity.

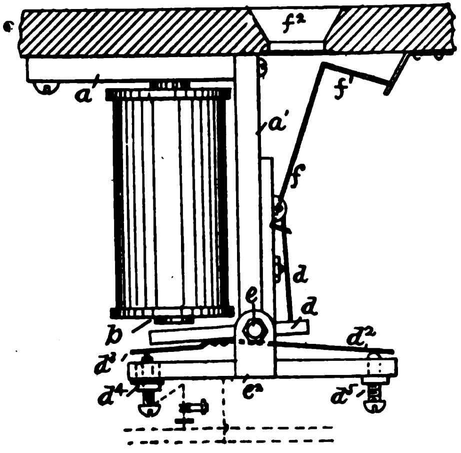


FIG. 2.

In Fig. 3 the coils b and c¹ on the cores b and c, respectively, are wound in the same direction and also in such a direction that a positive current from line 2 through both coils b and c will make them have north polarity, tending to repel the north polarized armature, and thereby to close the receiver circuit at d; thus tending to unlock the telephone and to conceal the busy signal. A negative current through both coils b and c¹ would of course reverse the above action. There is also the coil c^2 on the core c wound in such a direction that a positive current through it from line 4 would develop a north polarity in c. It should be noticed that in the normal position of the armature r the coil c^1 is shunted by the wire 8, armature r, and wire 9.

Thus, when a negative current flows from line 2 through the coils b, q^1, and p^1 and a negative current flows from line 4 through the coils c^2, q^2, and p^2, both circuits being completed through the hook-switch and the ground, then the privacy switch g will attract its armature, open the circuit of the receiver and display the busy signal. Therefore negative currents from both line wires 2 and 4 lock out the telephone and do not ring the bell. A positive current through the same coils and circuits will cause the armature d to be repelled, thus closing the receiver circuit, thereby unlocking the instrument and concealing the busy signal.

If, however, after the armature d is left in its attracted position by negative currents previously sent over both lines 2 and 4, as just explained, a positive current be sent only over line 2, the cores of h will repel its armature and open the shunt 8-9 around the coil c^1. This coil, being then excited by a current in a suitable direction to develop a north polarity in the core c, will co-operate with the north polarity in the core b, developed by a positive current from line 2 through coil b, to repel the armature d and thus close the receiver circuit at d—i. e., unlock that particular station and conceal its busy signal. The repelling of the armature r will close the shunt 9-10 at r^2 around the coils p^1 and q^1, causing the armature r to be again attracted and producing the rapid vibration necessary for ringing the bell. This will continue as long as a positive current is sent over line 2. The action of this shunt around the bell magnet coils was explained in the description of the preceding patent.

By carefully tracing the direction of the positive current from line 2, used for ringing station No. 1 through all the magnet windings through which it can pass at the other five stations, it will be seen that none of their bell or privacy magnets will be energized sufficiently to cause any movement of the armatures. Thus No. 1 is the only station signaled and the only one whose receiver is connected to the line.

The arrangement of apparatus for station No. 2, which is called up by a negative current over line 2, is shown in Fig. 4. The coils p^3 and q^3 are connected in the circuit in such a direction that when a negatively directed current in line 2 passes through them to earth, they both produce north polarity in their cores, thus tending to repel that armature and ring the bell, and they will do so when no current circulates through p^4 and q^4. But p^4 and q^4 are connected in the circuit in reverse direction with respect to each other, so that current in them in either direction from line 4 produces opposite polarity in their respective cores. Thus if current flows in all four coils, in p^3 and q^3 from line 2 and in p^4 and q^4 from line 4, no matter in which direction, the resultant polarity of the cores is such as to attract and not to repel its armature, and therefore under such conditions the bell will not ring.

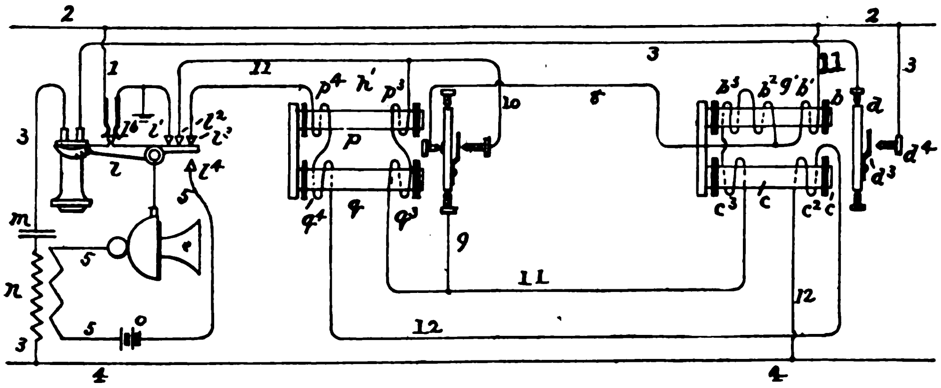
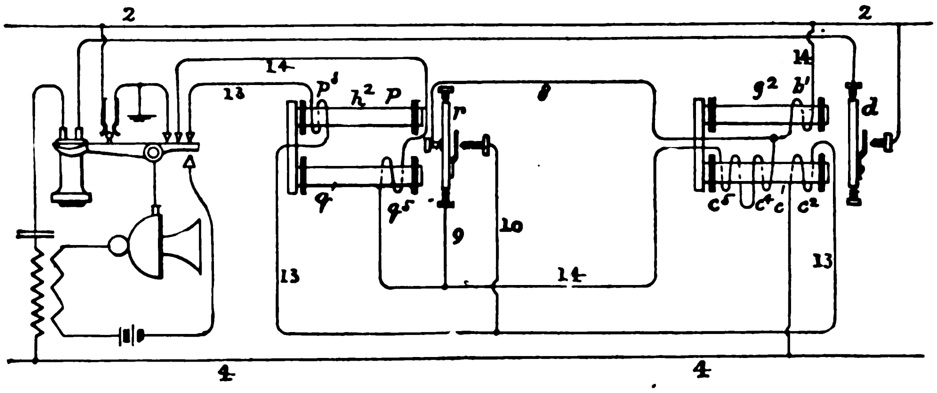


FIG. 4.

Coil b^1 is wound in such a direction that a negatively directed current through it produces south polarity in its core, tending to attract its armature, and a negatively directed current through c_3 produces south polarity in its core, consequently negative currents from both lines 2 and 4 through coils b^1 and c^2 only, to earth at this station will attract the armature d, thus cutting out the receiver at this station, but positive currents from lines 2 and 4 through these same two coils would repel the armature, and connect the receiver to line 2 again. Coils b^2, b^3 and c_3 are all wound in the same direction with respect to each other, but in an opposite direction with respect to coils b^1 and c^2, thus producing north polarity in both cores when a negative current from line 2 circulates only through b^1, b^2, b^3, and c^3. If, therefore, negative currents be sent through both line 2 and 4 in parallel, they will pass through coils b^1, p^3, and q^4 from line 2 to earth and c^2, p^4, and q^4 from line 4 to earth, the resultant action will be to attract the armature d and cut out the receiver. If then a negative current be sent over line 2 only, it will pass first through coils b^1, p^3 and q^3 only. This will cause the armature of h^1 to vibrate and ring the bell, and furthermore, when it is repelled it opens the shunt circuit through wire 8, compelling the current to pass through coils b^2, b^3, and c^3 in addition to b^1. Now b^2 neutralizes the effect of b^1 because they are wound in opposite directions, and the negative current through b^3 and c^3 repels the armature and thus closes the receiver current. Thus the negative current from line 2 rings the bell and cuts in the telephone receiver. This negative current over line 2 alone will not ring the bell or cut in the receiver at any other station.

The connections and windings for station No. 3, which is called up and cut into the circuit by a positive current only through line 4, is similar in all respects to those at station No. 1, shown in Fig. 3, except that the wire 6 is connected to line 4, and wire 7 to line 2. The reader, if anxious to verify this point, will find by tracing out the proper currents through their circuits, that this change in the connections will ring the bell and cut in the receiver only at station No. 3. Similarly the windings and connections for station No. 4, which is called up and cut into the circuit by a negative current over line 4, is similar in all respects to those at station No. 2, shown in Fig. 4, except that the wire 11 is connected to line 4, and wire 12 with line 2.



FI G 5.

Fig. 5 is the diagram of connections for the fifth station, which requires a positive current over line 2 returning through line 4, that is a negative current in line 4. The two coils b^1 and c^2 are wound in the same direction over their respective cores, this direction being such that negative currents through both of them from lines 2 and 4 respectively will produce south polarity in each core of g^2. Thus, if there is no current in the coils c^4 and c^5, the armature d will be attracted and the receiver cut out of circuit. This will be the case when the armature r is in its normal position, short circuiting by wires 8 and 9 the two coils c^4 and c^5. Coils p^5 and q^5 are wound in such a direction over the cores p and q that either negative or positive currents over lines 2 and 4 in parallel and going to earth at this station, will produce opposite polarities in their respective cores, thus not affecting the armature, which will remain in its normal attracted position, keeping the coils c^4 and c^5 short circuited. This is necessary in order to cut out the receiver by negative currents over both line wires in parallel. But if a positive current is sent over line 2, returning to the central office through line 4, giving positive and negative currents in lines 2 and 4 respectively, it will pass through coils q^5 and p^3 in directions which will produce north polarites in both cores of h^3, repelling the armature and on account of the shunt wires 9 and 10 which short circuit both coils q^5 and p^5 in the repelled position of the armature r, the armature r will vibrate and ring the bell. The first time that the armature is repelled the current from line 2 will be forced to pass not only through coil b^1 but also through coils c^4 and c^5 because the wire 8 is open circuited at the armature r. Now c^4 and c^5 are both wound in the same direction, but reverse to c^3, so that when a positive current flows through them, through wires 14, 9 and 10, to and through coil c^3 and back to the central office through line 4, one of the two coils c^4 or c^5, say c^4, exactly neutralizes the magnetizing effect of coil c^3 upon the core c, leaving the remaining coil, c^5, to magnetize the core. Furthermore, positive current from line 2 through coils b^1 and c^5, which alone need be considered, since in the repelled position of the armature r the current in coils c^4 and c^3 neutralize each other, will produce north polarity in both the cores of g^3 and thus, by repelling the armature d, cut in the receiver at this station. Therefore this station bell is rung and the receiver connected properly to the circuit by a positive current from line 2, which returns to the central station through line 4, the ground return not being used by the signaling current. And, moreover, the current and line combination, as just mentioned, which will signal this station No. 5, will not ring up any of the other five stations.

The circuits for the sixth station are like those for the fifth station, as shown in Fig. 5, except that the wire 14 is connected to line 4 and wire 13 to line 2.

Fig. 6 is a diagram of connections for the circuits of the bell and privacy switches at the six stations I, II, III, IV, V, and VI, with eight keys at the central office, the first six for selectively calling any one of the six subscribers, the seventh marked U for restoring the connection of the receivers at all six stations to the line, and the eighth L for disconnecting or barring all telephone receivers from the line. In practice, the first step in the process of calling a station is to depress key U, thereby sending negative currents over both lines 2 and 4 to earth at every station and thus disconnecting the receivers from the line, or locking them out, as it is termed, at all stations. Then the operator rings the bell of any desired station by pressing the corresponding key. When a conversation is finished the operator depresses the key U, which sends a positive current over both line wires 2 and 4 to the ground at all stations, thereby connecting the receivers to the line and concealing the busy signal at all stations.

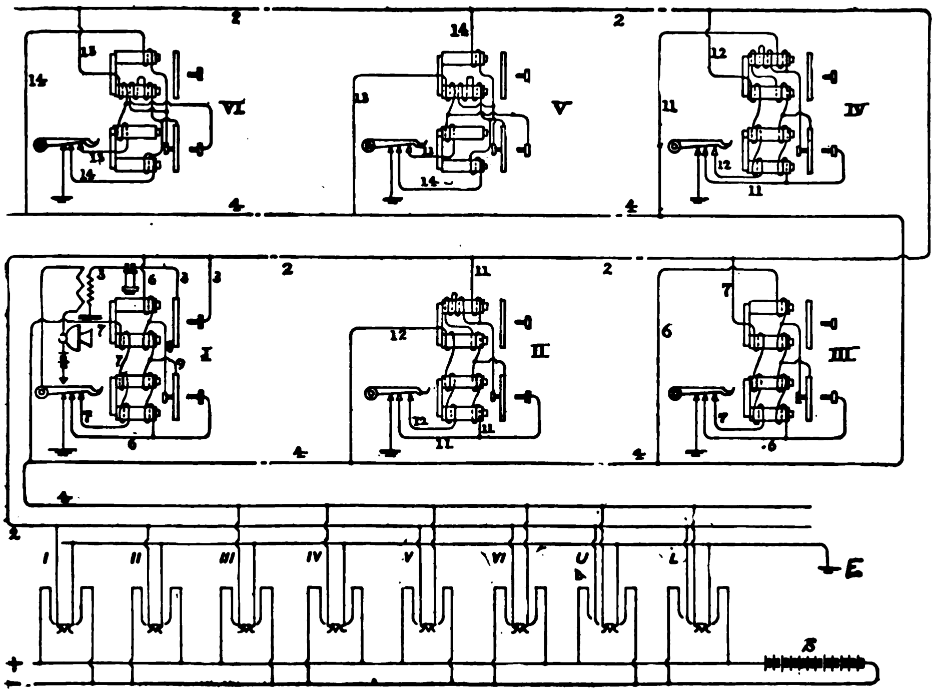


FIG. 6.

This selective signaling system of Barrett's is now in use at several telephone exchanges. The current which flows through the two line wires all the time when none of the instruments are in use is quite generally supplied by gravity cells, two sets in parallel, each set containing about sixty-one cells—that is, about sixty volts between the annunciator and the ground. This is the battery which enables the subscribers to call up the central exchange. The operators require about 100 volts to ring up the subscriber and seventy volts for locking and unlocking the instruments. For these purposes, in at least two exchanges, Leclanche cells are used. The keys for locking and unlocking are not push buttons like the selective ringing keys, but are cams and are placed in the middle of the operator's table. These party lines are frequently all handled at one section. At this section there are three plugs instead of two, two for insertion into party line jacks, and one for insertion into the ordinary jacks. So that if two subscribers both on party lines are talking together, the two party line plugs are in use; but if a party line subscriber calls up a private line subscriber, then one party line plug and one ordinary plug are in use. There is only one ordinary ringing key required. It is connected to the ordinary plug for ringing up the private line subscriber. The selective ringing keys are normally so arranged as to send current through only one of the party line plugs, say the front calling plug. They can, however, by holding down another special key, be thrown into connection with the other party line plug. This is only used when the original subscriber has left his telephone and it is necessary to call him up again. Of course, there are ten duplicate sets of these three plug circuits with the one ordinary ringing key at each operator's position just the same as there are ten or fifteen duplicate pairs of plugs on the ordinary section, but the six selective ringing keys, the locking and unlocking cams and the special key mentioned above are not duplicated. In some cases the locking, unlocking and busy signal part of the device has caused trouble and has been temporarily or permanently removed, retaining, however, the selective ringing feature.

BALANCING THREE-WIRE SYSTEMS WITHOUT USING 110-VOLT DYNAMOS.

In three-wire systems using generators wound for the full voltage between the positive and negative or outer conductor of the system, the balance or exact division of the voltage each side of the neutral can be maintained by storage batteries, into the center of which the neutrals are connected. An unequal division of the load between the two sides of the system would in such a case gradually discharge either the positive or negative side of the battery below the other side and cause an inequality of voltage. This may be obviated if the load is almost equally divided, by providing a small two-wire load, such as the station lighting circuit, engineer's residence, etc., and throwing this on the proper side to equalize the average battery duty.

INTERIOR WIRING.

BY CHARLES E. KNOX.

SWITCHBOARDS.

In this number we will consider and describe a switchboard recently installed in connection with an isolated plant in an uptown building in New York City. The arrangement of the switches, circuit-breakers, instruments, etc., on the front of the board, and of the bus-bars, lugs, connections, etc., on the rear of the board, is shown in Fig. 1. The connections of dynamos, switches, bus-bars, etc., are shown diagrammatically in Fig. 2.

Purpose of Switchboard.—The switchboard here shown serves to operate and control three direct-current, compound-wound dynamos, and also to control and protect the various feeders originating at the switchboard. The dynamos constitute the sole source of current supply, as there is neither a storage battery nor a street supply connection used to supplement the plant. Two of the dynamos are of 50 kw. and one of 25 kw. capacity.

Current is used for both lighting and power. The power circuits supply motors for elevators, dumb-waiters, ventilating fans, etc.

Arrangement of Panels.—As will be seen from Fig. 1, the switchboard is divided into three panels. The main or central panel serves for all the generating switches and appliances; the right-hand panel (facing the board) serves for the lighting feeders; the left-hand panel serves for the power feeders.

Each of the panels consists of a single slab of marble, from 1¾ inches to 2 inches in thickness, the width varying to suit the appliances installed thereon. The edges of the panels are finished so that when the panels are "butted" together, no crack or seam is visible between them.

Dynamo Panel.—The dynamo (central) panel consists of a single slab of marble, four feet in width and seven and one-half feet in height.

By an inspection of Fig. 1 it will be seen that there are two sets of main bus-bars, and that each dynamo connects with two switches, one placed above the other. The object and method of operation of this duplicate set of bus-bars and switches will be described later.

Each of these sets of bus-bars consists of three separate bars, indicated by the letters P, E and N in Fig. 1. These letters P, E and N represent the positive, equalizer and negative bus-bars, connecting respectively with the left, middle and right hand studs of the dynamo switches.

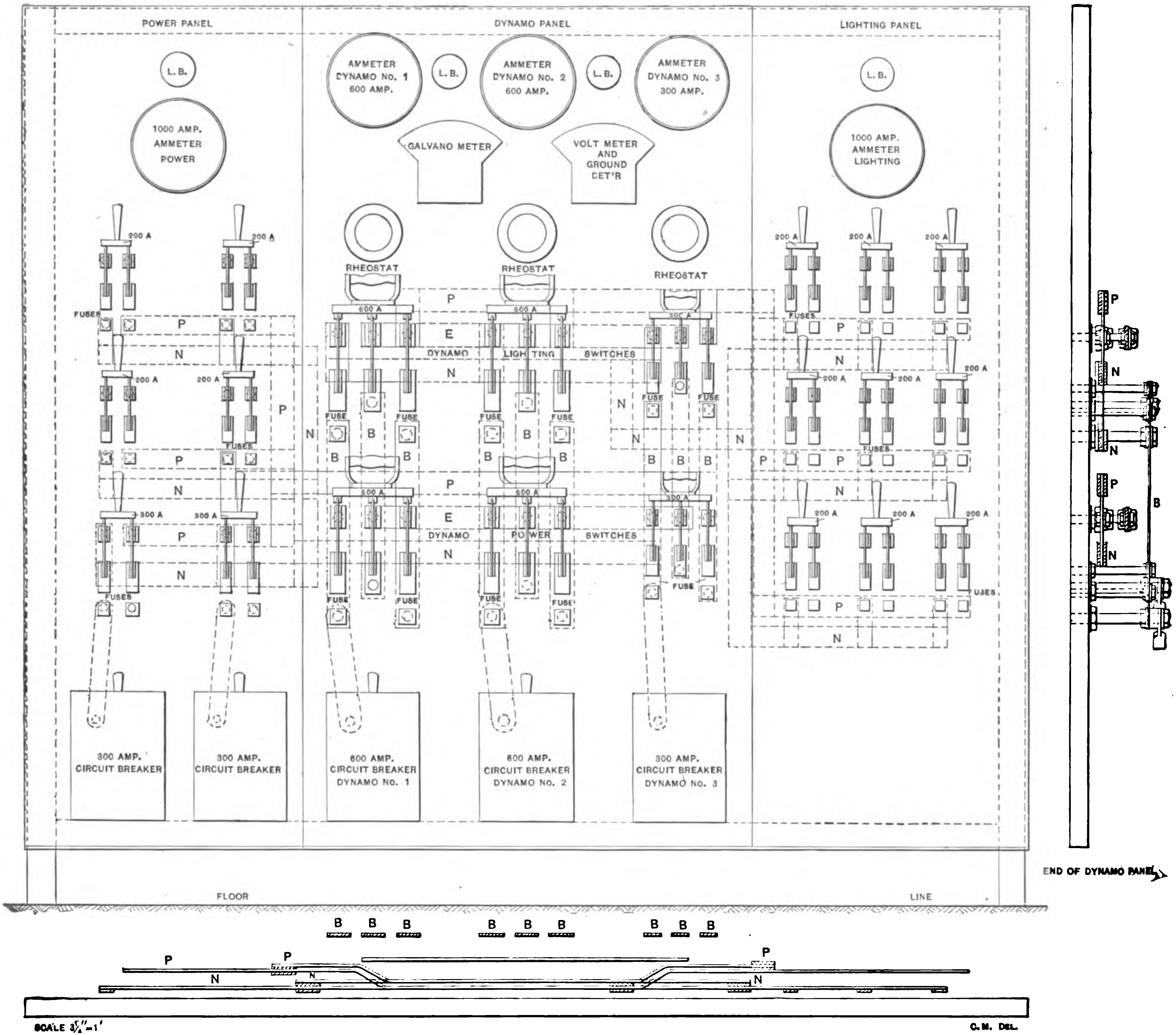

POWER PANEL
DYNAMO PANEL
LIGHTING PANEL
L. B.
1000 AMP. AMMETER POWER
AMMETER DYNAMO No. 1 600 AMP.
AMMETER DYNAMO No. 2 600 AMP.
AMMETER DYNAMO No. 3 300 AMP.
GALVANO METER
VOLT METER AND GROUND DET'R
1000 AMP. AMMETER LIGHTING
RHEOSTAT
200 A
300 A
600 A
FUSES
FUSE
P
E
N
B
DYNAMO LIGHTING SWITCHES
DYNAMO POWER SWITCHES
300 AMP. CIRCUIT BREAKER
600 AMP. CIRCUIT BREAKER DYNAMO No. 1
600 AMP. CIRCUIT BREAKER DYNAMO No. 2
300 AMP. CIRCUIT BREAKER DYNAMO No. 3
FLOOR
LINE
END OF DYNAMO PANEL
SCALE ¾"=1'
C.M. DEL.

FIG. 1.—FRONT ELEVATION AND VERTICAL AND HORIZONTAL SECTIONS OF A SWITCHBOARD WITH POWER AND LIGHTING BUSES AND EQUALIZERS.

It will also be seen in both Figs. 1 and 2, that while the positive and negative bus-bars extend and connect with the side (feeder) panels, that the equalizer bus-bar only runs between the dynamo switches. As the purpose and utility of the equalizer connection is not understood or appreciated by the average wireman (and sometimes even by the switchboard attendant) it might be well here to briefly describe its object.

In running two or more compound-wound dynamos in multiple, it frequently happens that the voltage of one dynamo, for some reason (such as change in engine speed for example) will rise above the voltage of the other dynamo. If these two dynamos were connected together merely by the positive and negative connections, the dynamo having the higher voltage would tend to reduce the voltage of the other dynamo for the reason that it would send current through the other machine in such a direction as would tend to reduce or to neutralize the field of the latter machine. The result of this would be, of course, to still further widen the gap in voltage between the dynamos, and trouble would immediately follow. Now by running a connection from one machine to the other, between the negative and positive connections, this tendency of neutralizing the field of the dynamo having the lower voltage when the voltage of the two dynamos differs, is overcome or reduced to a minimum.[*]

It is for this reason, therefore, that triple-pole switches are used for the dynamos; the equalizer bus-bar connecting with the middle pole of each switch. As the equalizer carries but a comparatively small current and is never overloaded, no fuse is placed in the equalizer circuit.

As was stated above, some of the power circuits supply elevators and dumb-waiter motors. The power load is, therefore, in this case, a fluctuating load. As this frequently causes variations in the voltage of the generators, it is apt to interfere more or less with the lighting circuits. The amount of this interference depends on a great number of conditions, but in some cases it is sufficient to make it necessary to run the power and lighting circuits from separate dynamos. It is for this reason that two sets of bus-bars are used, one set serving for light and the other set serving for power. By having two dynamo switches for each unit, it is possible to run one dynamo on the lighting circuits and another one on the power circuits.

Either one of these dynamos may be transferred from one system to the other without starting an additional unit, or both machines may be run in multiple on both systems, simply by closing all four switches; or one dynamo may run both power and lighting circuits by simply closing both switches connected with that dynamo. The bars marked B on the plan serve to connect the lower studs of each set of dynamo switches together. Each dynamo is equipped, in addition to the switches, with a circuit breaker, an ammeter and a rheostat. The circuit breaker is, of course, placed in the negative lead. There is also a voltmeter which serves as a ground detector as well, and a galvanometer (a double differential coil voltmeter having the zero in the center of scale) which is used when throwing the dynamos in multiple, to ascertain when they are at the same voltage.

Diagram of Connections.—Fig. 2 shows all the connections at the switchboard between the dynamos and the various bus-bars, and the connections with all the appliances.

The vertical and horizontal sections, shown respectively at the side and bottom of Fig. 1, show the arrangement and connections of the bus-bars, studs, lugs, connections, etc.

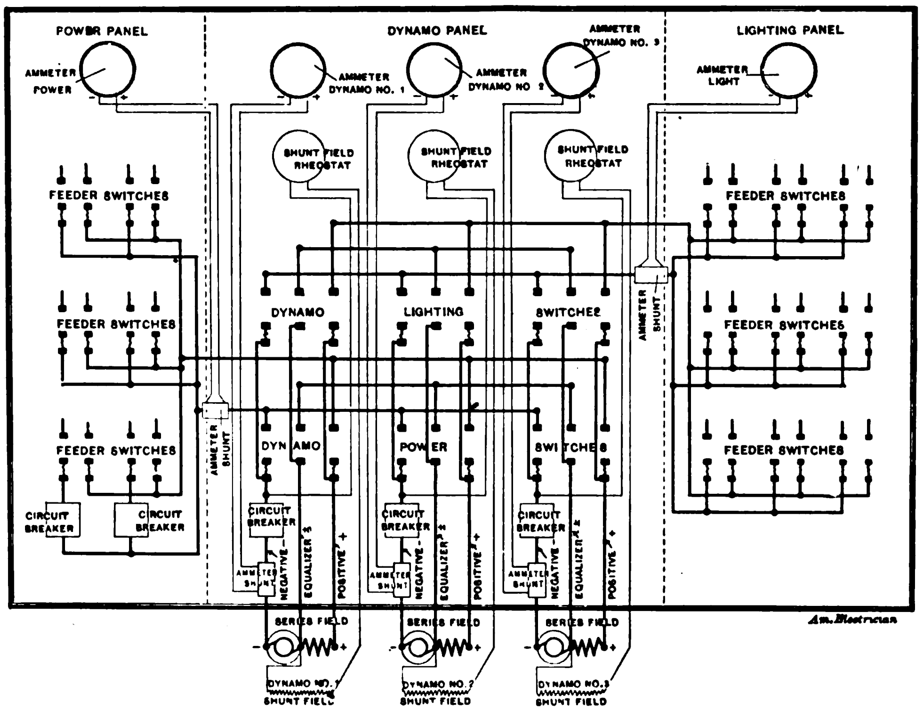

POWER PANEL
AMMETER POWER
DYNAMO PANEL
AMMETER DYNAMO NO. 1
AMMETER DYNAMO NO 2
AMMETER DYNAMO NO. 3
LIGHTING PANEL
AMMETER LIGHT
SHUNT FIELD RHEOSTAT
SHUNT FIELD RHEOSTAT
SHUNT FIELD RHEOSTAT
FEEDER SWITCHES
FEEDER SWITCHES
FEEDER SWITCHES
FEEDER SWITCHES
FEEDER SWITCHES
FEEDER SWITCHES
DYNAMO
LIGHTING
SWITCHES
DYNAMO
POWER
SWITCHES
AMMETER SHUNT
AMMETER SHUNT
CIRCUIT BREAKER
CIRCUIT BREAKER
CIRCUIT BREAKER
CIRCUIT BREAKER
CIRCUIT BREAKER
AMMETER SHUNT
AMMETER SHUNT
AMMETER SHUNT
NEGATIVE
EQUALIZER
POSITIVE
NEGATIVE
EQUALIZER
POSITIVE
NEGATIVE
EQUALIZER
POSITIVE
SERIES FIELD
SERIES FIELD
SERIES FIELD
DYNAMO NO. 1
SHUNT FIELD
DYNAMO NO. 2
SHUNT FIELD
DYNAMO NO. 3
SHUNT FIELD
Am. Electrician

FIG. 2.—WIRING DIAGRAM OF SWITCHBOARD SHOWN ON PREVIOUS PAGE.

Lighting Panel.—The lighting panel consists of a slab two feet six inches by seven feet six inches. On this slab are mounted nine two-hundred-ampere double-pole switches, each of which serves for connection with a lighting feeder.

The upper set of bus-bars on the dynamo panel extend to the lighting panel where they connect with a vertical set of bus-bars, which in turn connect with the three horizontal pairs of bus-bars, corresponding with the three rows of switches. The main lighting negative bus-bar is interrupted at the point shown (see Fig. 2) for the insertion of the ammeter shunt, which measures the total amount of current consumed for lighting. The ammeter is mounted at the top of the panel.

Power Panel.—The power panel consists of a single slab having the same dimensions as the lighting panel. On this panel are mounted six double-pole switches, four having a capacity of two hundred amperes, and two (the lowest row) having a capacity of three hundred amperes. The arrangement of the switches, ammeter and the connections for the ammeter shunt (which in this case measures the total amount of current used for power) is very much the same as for the lighting panel. The bus-bars for this panel, of course, connect with the lower or power set of dynamo bus-bars. It will be noticed that the feeders connecting with the lower pair of switches are protected by circuit breakers in addition to the fuses. The reason for this is that these feeders supply two large motors and it was thought best to provide protection (other than the fuses) for a sudden overload on these motors. It was not deemed necessary to place any circuit breakers on the other feeder circuits, as the motors which they supply are smaller and less liable to sudden or serious overload.

Switchboard Frame.—The entire switchboard is mounted on and secured to a substantial angle-iron frame. At both ends of the switchboard and at the junction of the panels, the angle iron is fastened to substantial T bars or small beams, which extend both above and below the switchboard.

At the lower end these bars are secured to iron foot plates "grouted" into the concrete. At the upper end the bars fasten to the ceiling beams. The entire structure is stiffened and made rigid by horizontal stays, fastened to a wall back of the switchboard.

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[*] If the reader wants a fuller explanation of this effect he will find it fully described with diagrams in S. P. Thompson's "Dynamo Electric Machinery."

THE ELECTROLYTIC PRODUCTION OF SODA AND CHLORINE.

FIRST PAPER—INTRODUCTORY.

BY JAMES F. HOBART.

The production of metals and chemicals by electrolysis has become so large an industry, and is employing such important machinery and processes, that it engages a considerable portion of time and thought on the part of electrical engineers. So comparatively new is the field, that every engineer who enters it must go over considerable preliminary ground before he can attempt research in the particular line he desires to enter.

For instance, a number of paper mills are putting in plants for the production of chlorine and soda. An electric plant is needed for the decomposition of salt (chloride of sodium) from which the desired chemicals are to be made. In connection with this work, how big a plant is needed? How much current? How many volts pressure? These questions must be answered before the proper dynamo and machinery can be selected.

Again, before this last problem can be solved, we must investigate the electrolytic process, and from its requirements determine the pressure and voltage required. It is necessary to go still further back, for before electro-chemical work can be understood, we must study the ordinary chemical status of the materials to be used, and ascertain what reactions must be brought about in order to secure the desired results.

In the process of making chlorine and soda, common salt (chloride of sodium) being the substance to be treated, our investigations will for the present be confined to that salt alone. Any standard work on chemistry will tell that the symbol for chloride of sodium is NaCl. The first, Na, means sodium, the second member, Cl, represents chlorine. Equal parts of the two combine to form the compound NaCl. This may be proved as follows: Procure some caustic soda (NaOH) and make a solution in the proportion of 60 grams of the caustic soda in 500 cubic centimeters of water. Put in a glass dish a certain quantity, say 5 c. c. of the solution, and add a little at a time, 5 c. c. of muriatic acid (HCl), also called hydrochloride or chlorhydric acid; test with litmus paper, and if the chemicals are pure, the paper should show neither an acid nor an alkaline reaction, but the solution should be perfectly neutral.

If, however, the chemicals are not up to strength, a little more of one or the other may be added, so that the paper may remain immersed in the solution for one minute without showing a change of color. Both red and blue litmus paper should be used in this test, after which the solution may be evaporated and pure salt will be found in the dish.

In the above example, chlorine and sodium have been united and chloride of sodium is the result. Chemists will express the operation in a single algebraic formula, thus: $Na + Cl = NaCl$; according to the chemical reaction that $NaOh + HCl = H_2O + NaCl$. Thus the result of the combination is salt and water, forming a saline solution.

Having shown that common salt consists of soda and chlorine, the next step is to find a way of separating the two elements, that they may be applied to the work they are required to do, which in paper making is, bleaching and digesting paper stock in order to make clean and white paper.

To recover chlorine from the salt, we can treat it with sulphuric acid, causing the chlorine to unite with the hydrogen of the sulphuric acid to form muriatic acid, and the soda to unite with the sulphur and oxygen of the acid to form sodium sulphate. The reaction is as follows:

Chloride of Sodium $= NaCl$.
Sulphuric Acid $= H_2SO_4$.
Then:
$2\ NaCl + H_2SO_4 = Na_2SO_4 + 2\ CHl$.
$Na_2SO_4 =$ Sodium Sulphate.
$HCl =$ Hydrochloric Acid.

In the above operation, the hydrochloric (muriatic) acid could be made useful if it were possible to drive off the hydrogen; thus Muriatic Acid $= HCl - H = Cl =$ Chlorine; but this cannot easily be done because of the great attraction of chlorine for hydrogen, its affinity for that gas being very strong. Therefore the chlorine must be obtained directly from salt by adding some other substance which will cause the hydrogen to be otherwise disposed of.

There is plenty of oxygen in air, and it seems at first sight that if the acid should be exposed to the atmosphere the oxygen should combine with the hydrogen of the acid, forming water and chlorine, thus $2\ HCl + O = H_2O + 2\ Cl$; but it will not, the affinity of chlorine and hydrogen being too great. It can be done, however, on a large scale by well-known processes now employed for the manufacture of caustic soda and bleaching powder. As these processes do not involve the use of electricity, their details will not be gone into.

By the electrolytic process, salt is separated directly into its component parts. When the terminals of an electric circuit are placed in a vessel of water that fluid (if there is current and pressure enough) will be decomposed into its component parts—oxygen and hydrogen. When electricity is passed through a solution of salt the sodium and chlorine are separated, one going to either terminal, and the reaction is $NaCl = Na + Cl$.

In order to thoroughly comprehend this matter so as to be able to properly design or select the necessary electrical machinery and apparatus, it is desirable that the action and reaction, electrical and otherwise as well, be fully sought out and understood, and that the "reason why" and the "know how" be fully brought to light. To do this comprehensively, we must go to the very bottom of things and wrestle with the molecules and atoms of matter composing the soda, the chlorine and the salt.

We are told that one ampere of current, in one second of time, will throw down or deposit .00023873 gram of sodium; also, that with the same current, in the same length of time there will be liberated .00010384 gram of hydrogen. From the data above given (the hydrogen) we can calculate the amount of current which will be required to liberate any given quantity of any required element in any stated time. But before we can go to this matter, we must study how electrolysis is brought about.

In composing or decomposing sodium or any other substance, either by electrical or chemical means, we must first reduce the mass to the smallest divisions possible. That is, we must go down to the atom. This means something which cannot be cut, and it is generally believed that material atoms cannot be divided, and that they are absolutely unalterable in size, shape, weight and density; that they can neither be cut, scratched, flattened or distorted; and that they are unaffected in size, density or shape by any known physical force, either heat, cold, electricity or light.

The atom, then, is like the litle cube with which many of the mosaic floors are built. By combining many of the little cubes into various shapes, the pleasing figures and groupings are formed, but none of the "atom cubes" are to be cut or otherwise changed in shape. They are to be combined in different ways, that is all. In like manner, in chemistry, we combine the atoms of different substances into the many substances known to the art. In electro-chemistry, we confine our work to the atom, for in separating elements, as in combining them, if we can handle two atoms to our satisfaction, the combination or decomposing of millions of atoms or tons of matter is only a matter of time and multiplication.

The exact size of an atom has probably never been determined, but we can gain some idea of one by thinking how small would be the smallest quantity of air that can be imagined. It would be infinitesimal, yet after the bit of air had been divided and subdivided to the utmost, it would not even then be an atom, but a molecule. This is because air is composed of two parts, oxygen and nitrogen. Thus the smallest conceivable particle of air would be a molecule, which in turn could be divided into three parts, two of nitrogen and one of oxygen.

Some idea of the size of atoms has been given by Sir William Thomson, who figures that the smallest visible organic particle—1/4000 of a millimeter in diameter—contains about 30,000,000 atoms, or a 5-cent nickel, which is about two centimeters in diameter, and has an area of 3.1416 square centimeters, would permit "standing room" for upward of 19,200,000,000 atoms.

In the electrolysis of salt, we have to deal with just two of these little atoms, one of chlorine, the other of soda. But all the atoms do not have the same weight. Hydrogen is the lightest substance among the 70 known elements, therefore the weight of an atom of hydrogen is called 1, and the weights of the atoms of all the the other elements are considered in relation to or in comparison with that standard.

An atom of Chlorine (Cl) is 35.4 times as heavy as an atom of hydrogen, hence the atomic weight of hydrogen is 1, while that of chlorine is 35.4. By the same rule, the atomic weight of sodium (Na) is 39.1, therefore the weight of a molecule of chloride of sodium (NaCl), one atom each of the two elements, is $35.4 + 39.1 = 74.5$. The value of this system of atomic weights is to determine the proportion by weight of the elements in a substance; thus, in NaCl, 1000 parts would contain $1000 \times 35.4 \div 74.5 = 475.17$ parts Cl, and $1000 \times 39.1 \div 74.5 = 524.83$ parts Na.

It has been observed that the atoms of some elements require more or less of atoms of other elements to effect perfect combination. And again, sometimes different atoms will combine in different proportions with atoms of other elements. For instance: in water, H_2O, two atoms of hydrogen are required to form a combination with one atom of oxygen. But one atom of oxygen can, in some instances, combine with an atom each of two other elements, as in hydrochloric, HC 1 O, where an atom of oxygen combines with an atom each of hydrogen and chlorine.

This property of holding, or combining with one or more atoms, is called "valency," and, as stated above, it means the worth or value of the atom, in the number of hydrogen atoms which it can displace or decompose. The valency of some elements is 1, of others 2 or 3. Hydrogen has a valency of 1, Oxygen, 2.

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FEED WATER PURIFICATION.

Although the papers upon grease extraction, in the January and February issues of The American Electrician, may be taken as pertaining to feed water purification, the methods discussed herewith will pertain to the separation of the salts of various substances from water as received from rivers and wells, in which the salts are so combined that they form incrustation in the steam boiler, unless neutralized or separated either in the boiler or before the feed water reaches the steam generator. The subject may then be divided into two parts, viz., the purification of feed water by removing the foreign or troublesome salts before the feed water reaches the boiler, and, second, the neutralization of the impurities inside of the boiler, by the use of so-called boiler "compounds."

The first method may be divided into several entirely different ways, according to the method of procedure, such as precipitating the salts in tanks before the boiler is reached, or by filtering; also, by the use of live steam heaters, in which the incrusting matter is thrown down by the action of heat, being deposited upon pans or other surfaces specially prepared therefor. In this case, the action is much the same as that which takes place when the matter is deposited upon the tube and sheet surface of a steam generator.

The second method embraces the plans of treating the water with various boiler compounds; also, of separating the contained impurities after precipitation, by means of skimming dishes and separators. When this operation is performed by apparatus inside of the boiler it may be taken as belonging to the second class or method, but when the same apparatus is placed in a separate containing vessel outside of the boiler, and the conditions made the same as when done inside the steam generator, then the operation belongs to the first class or method. The method and manner of using that method must be determined by the chemical composition of the particular water to be dealt with; therefore, an analysis of the water is the first thing to be secured. Once that is at hand, intelligent work may be done. Without the analysis, the work done is merely "cut and try." Even with a good analysis of the water, there is another thing to be looked after, and that is, what reactions will take place in that water under the conditions of heat and pressure as sustained by water in a steam boiler. There may be chemical reactions taking place under these conditions which will render worthless a chemical compound prepared strictly according to the "cold analysis." In the case of iron pyrites, as noted in a paper by J. H. Parsons, in the September (1899) issue of this paper, this matter comes up. There it is necessary to ascertain how much free sulphuric acid will be derived from the sulphate of iron and sulphate of copper in water under the pressure and heat conditions met with in the boiler. But that alone will not do. It must also be ascertained what amount of the free acid will combine with the lime and magnesium contained in the water, and how much of the free acid will be left to attack the shell plates of the boiler. Thus the bare analysis of the water is nearly useless. It is a "working analysis" that is wanted.

In the paper quoted (by Mr. Parsons) an illustration is shown which is reproduced herewith as Fig. 1. In this arrangement there are two tanks, each of which will hold at least water enough for a day's run. The necessary chemicals for neutralizing the amount of impurity contained in a tank full of water is then introduced into the first or precipitating tank, and allowed to act for 24 hours, after which the water is run into the second or supply tank, and kept there until required in the boiler. This is a very good method of purifying water, but unfortunately it seems to infringe upon patents controlled by the Continental Filter Company, New York. This company has patented the matter of precipitating water at rest. Formerly it was customary to add the precipitating or coagulating chemical to the water as it passed into the filter or settling tank, but by the patents quoted this company secured the right to add the chemicals to the water while at rest in a separate tank from the filtering or precipitating vessel.

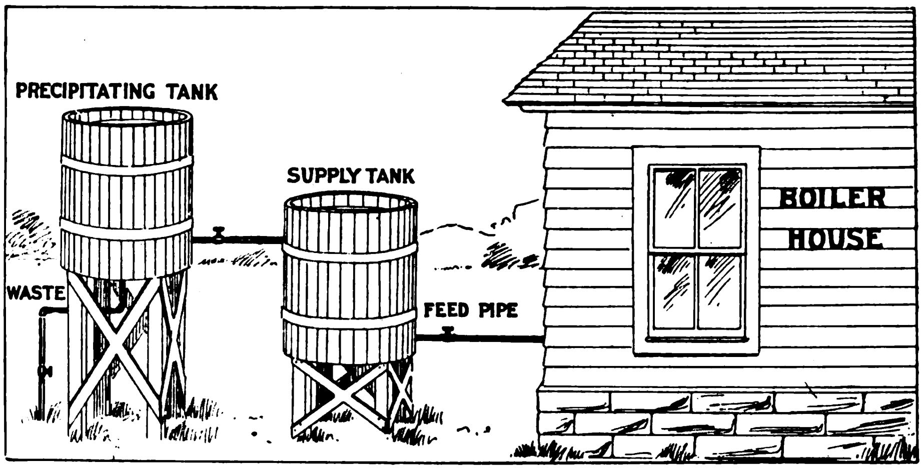


FIG. 1.—PARSONS'S ARRANGEMENT FOR PURIFYING FEED WATER.

Acids may be neutralized in the manner illustrated above, also the salts of lime and magnesium—the sulphates and carbonates—silicia, iron and salt, waters of more than 150 grains of solids to the gallon, may be relieved of at least 75 per cent. of their scale forming and corrosive properties in the manner described. But when the waters are very strongly alkaline, then a different treatment may be employed. Fig. 2 shows an arrangement for this purpose, as manufactured by F. E. Kennedy & Co., St. Paul, Minn. It works upon the principle that pure water can be drawn from the top of a vessel in which alkaline water is subjected to heat and steam, the alkali being concentrated and precipitated. This form of cleaner may be placed in the smoke box, or in any other place where it will be exposed to a considerable degree of heat. It is then more of a feed water heater and purifier than a boiler cleaner, but it may also be located in the steam space of a boiler, when it will act somewhat in the line indicated by the title of this paper. The action of the device is as follows: The water is first heated to set free the alkali or other materials and then is applied to the hottest portion of the body of the water. The alkali and other materials set free by the heat tend to come to the surface, in the form of a creamy-like foam, and when the free steam is applied directly thereto a churning action is set up which has the effect of concentrating the alkali and other materials into a solid form, which will then fall by gravity to the bottom of the receptacle in which the water is receiving treatment. The separator can be readily taken down and removed from the boiler. The flues are also of such character and so applied as to permit the same to be readily removed and replaced by new ones whenever so desired.

To the above-mentioned methods of feed water "cleansing" may be added the use of feed water "heaters and purifiers." In fact, about all the heaters, and they are almost numberless, "purify" the feed water to a certain extent. This matter is, however, so extensive that a separate treatment of feed water heaters is necessary, and the appliances for that purpose will be described later.

In the matter of the internal precipitation of feed-water impurities by means of so-called "boiler compounds," there are three kinds of action to be described. A very full treatment of this matter was printed in the American Machinist of Dec. 7, 1899, by Albert L. Cary, who gives the chemical composition of many of the common scale-making water impurities. We will, however, quote Mr. Cary when he says that the ordinary "boiler compounds" are divided into three classes:

First, those attacking the scale-producing material chemically and acting as reagents, combine with the matter precipitated from the feed water, forming a third substance different from either the original precipitated solids or the "reagent," the theory being that the new substance will not form into a hard, resisting scale, and therefore can be more easily removed by blowing off or by the cleaning tools used after the boiler is opened up.

Second, those acting mechanically upon the precipitated crystals of scale-making matter soon after they are formed. Such "compounds" are of a glutinous, starchy or oily nature, and become attached to the surface of the newly formed crystals (precipitated from the water surrounding them as the skin does the orange; and when those crystals fall together they are thus robbed of their cement-like action, which frequently occurs when they are allowed to come in immediate contact.

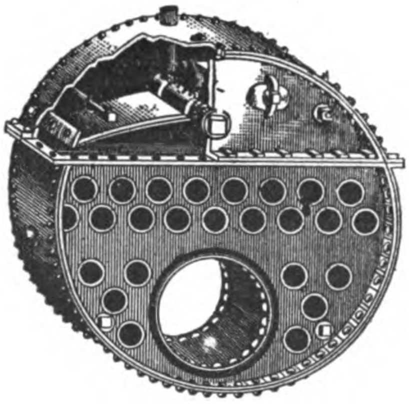


FIG. 2.—KENNEDY ALKALI SEPARATOR.

Third, those acting both mechanically (as just described) and also as a solvent, the latter action partially dissolving scale already formed, and by this "rotting" effect (as it is often called) preparing the scale for easy removal.

Mr. Cary adds that the "compounds" under the first division (which act chemically upon the scale-forming matter) also frequently accomplish this same rotting effect upon scale formed previous to their use. The principal ingredients used in such "compounds" are soda ash (or carbonate of soda) and tannin matters—and no good chemist would for a moment recommend tannin to be used in a steam boiler—and sometimes caustic soda, acetic acid, and other active agents harmful to the boiler and its fittings.

The action of soda, which may be called a "standard" boiler medicine for the sulphates of lime and magnesia, works in a very simple chemical manner, and as follows: The sulphate of lime and carbonate of soda change about so as to form in their places carbonate of lime and sulphate of soda, two substances which do not form scale, and which may be washed out of the boiler in the form of mud or sediment. In like manner, the sulphate of magnesium unites with the carbonate of soda to form carbonate of magnesia and sulphate of soda. These are also nonscaling.

In the matter of the second division of boiler purges, it is sufficient to state that they belong to the order of bones, or slipperly elm, potatoes, starch, and like material. Their action is never recommended by chemists who understand these matters fully. The third section contains a number of substances, of which kerosene oil may be taken as a representative, and also the best of that class. Kerosene acts by destroying the tenacity of the scale, or, in other words, by destroying its coherence, so that the deposit is thrown down and off the sheets by the ebullition of the water during the act of boiling. Kerosene is much better than crude petroleum for boilers, as the latter contains heavier material, such as tar or wax, which does not add to the effectiveness of the scale-removing operation.

There is a tendency toward the greater employment of external means for the purification of feed water, but in this matter Americans are far behind the engineers of Europeans, who employ the external methods to a greater extent. It would seem to be the ideal method of purifying water, to be able to throw down the lime and other mineral substances in much the same manner that organic substances are coagulated and precipitated by the use of alum. To this end, interesting experiments have been made by Martin L. Griffin, Mechanicsville, N. Y., as to the comparative value of certain reagents for removing lime and magnesia from natural waters for industrial uses. The results may be inspected by reference to the above table, which is reprinted from the August, 1899, issue of the Journal of the American Chemical Society.

The quantity of water or solution used was one-half liter, and the results are given in grams. To transpose to grains per gallon, use factor 58.38.

REAGENTS FOR REMOVING LIME AND MAGNESIA.

	Originally.		Aluminate.		Sodium hydroxide		Barium hydroxide		Sodium phosphate		Sodium fluoride.	
	Calcium Oxide.	Magnesium Oxide.	Calcium Oxide.	Magnesium Oxide.	Calcium Oxide.	Magnesium Oxide.	Calcium Oxide.	Magnesium Oxide.	Calcium Oxide.	Magnesium Oxide.	Calcium Oxide.	Magnesium Oxide.
Calcium sulphate solution	0.0720	......	0.0580	....	0.0720	......	0.0600	....	0.0140	....	0.0320	......
Magnesium sulphate solution	....	0.0610	....	0.0115	....	0.0349	....	0.0183	....	0.0610	....	0.0610
Magnesium chloride solution	....	0.0558	....	0.0082	....	0.0180	....	0.0558	....	0.0558	....	0.0558
Hudson River	0.0176	0.0050	0.0180	0.0048	0.0160	0.0043	0.0176	0.0046	0.0176	0.0050	0.0176	0.0050
Lake Champlain	0.0255	0.0070	0.0250	0.0068	0.0256	0.0064	0.0260	0.0060	0.0250	0.0057	....	....
Niagara River	0.0448	0.0129	0.0260	0.0118	0.0100	0.0097	0.0430	0.0100	0.0190	0.0130	....	....
Well in Mechanicsville, N. Y	0.0760	0.0263	0.0650	0.0237	0.0160	0.0147	0.0260	0.0150	0.0270	0.0234	0.0650	0.0240
Well in Mechanicsville, N. Y	0.0940	0.0334	0.0800	0.0236	0.0220	0.0133	0.0630	0.0029	0.0350	0.0338	0.0680	0.0278
Chazy Marble Lime Quarry, N. Y	0.0850	0.0150	0.0670	0.0136	0.0150	0.0111	0.0240	0.0115	0.0170	0.0115	....	....
Rock Well, Chazy, N. Y	0.1740	0.0248	0.0720	0.0208	0.0140	0.0188	0.0300	0.0146	0.0220	0.0172	....	....
Coxe Iron Mine, Drifton, Pa	0.0220	0.0518	0.0200	0.0516	0.0200	0.0000	0.0220	0.0064	0.0220	0.0518	....	....
Onondaga Creek, Syracuse, N. Y	0.3480	0.0298	0.0840	0.0014	0.1280	0.0043	0.0260	0.0028	0.0420	0.0288	....	....
Lime Quarry, Bowling Green, O	0.2080	0.0792	0.0080	0.0000	0.0090	0.0018	0.0680	0.0064	0.0250	0.0594	....	....

Letters on Practical Subjects

Fastening Conductors on Smooth-Body Armatures.

To the Editor of American Electrician:

Sir: I notice in the December number of your journal, page 561, volume XI., a note describing "A Novel Means of Fastening Conductors on Smooth-Body Armatures," and would like to point out that the construction you refer to was introduced by me some 10 years ago in Oerlikon for the Neuhausen generators.

Yours faithfully,
C. E. L. Brown.
Baden, Switzerland.

A Simple Means of Varying the Capacity of Parallel Fuses.

To the Editor of American Electrician:

Sir.—In order to replace at once a 350 amp. fuse, having on hand only No. 12 copper wire of a rated fusing capacity of 235 amp., application was made of the following scheme, which has proven of inestimable value in emergencies, and which incidentally brings forward a point with reference to parallel fuses, which is too frequently overlooked.

If two pieces of No. 12 copper wire of lengths proportional to 115 and 235 be connected in parallel there will be formed a fuse which will blow at 350 amp.

This is seen from the fact that when the shorter length is carrying 235 amp., 115 amp. will be flowing through the longer. The fusing of the shorter length will be immediately followed by the blowing of the longer.

The assumption that fuses placed in parallel will carry their combined capacities is a mistake quite often made. A case can be conceived in which the addition of a shorter length among a number of parallel fuses may lessen the capacity of the fuse as a whole. The fusing of the overloaded short length may cause a local heating of an adjacent long one, the melting of which will result in the blowing of the whole fuse.

A. S. McAllister.
Wilmerding, Pa.

One Cause of Trouble with Electric Gas-Lighting Apparatus.

To the Editor of American Electrician:

Sir.—I relate to you the following experience I have had on an electric gas-lighting job I completed in this city. For some time the owner of the house had been having trouble with the gas lighting; the burners would light at times and then again would not. Of course whenever this occurred I was sent for, and on arriving at the residence found everything in good working order. Finally one evening I tested for a short circuit but found everything clear. I then tried the pendant burners and found that they worked perfectly. I then proceeded downstairs and tried another burner and found that it would not ignite the gas. I now tested for a short circuit and found that there was one.

Just by accident I tried the burner in one of the chambers on the second floor and found that some one had left a wire picture-holder hanging on the side arm and that the insulation on the fixture wire had been rubbed off by constantly removing and replacing the wire holder, causing the current to traverse holder and onto the gas fixture from the extremity of holder which touched same. Whenever they would take the holder off of fixture the short circuit would be off and whenever they would hang same on gas fixture it would cause a short.

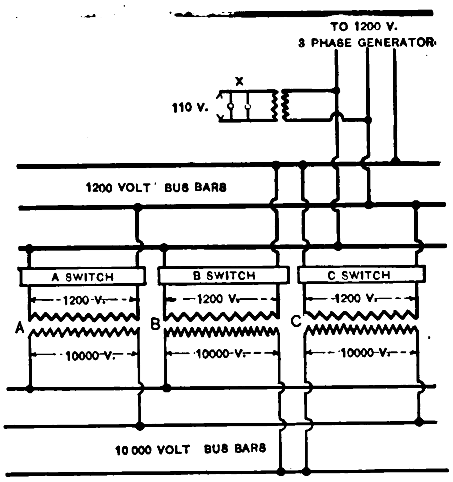
Hoping that some of your readers may derive some benefit from my experience, I remain, Yours respectfully,

F. H. Evert.
Rochester, N. Y.

A Polyphase Puzzle.

To the Editor of American Electrician:

Sir.—Having waited in vain for an answer to the puzzle which appeared on page 531 of the American Electrician of November, 1899, I will venture my opinion as to its solution. First, the fuse on the right-hand wire from the 1200-volt generator was blown. Second, switch B closed gave no light at x. Third, switches A and B closed gave full light at x. Fourth, switches A, B and C closed gave half candle power at x.



A POLYPHASE PUZZLE.

A. R. Coleman.
Indianapolis, Ind.

[Mr. Coleman's solution of the problem is undoubtedly wrong, since if only the one fuse in the right-hand leg from the 1200-volt three-phase generator were blown, current would come through from the generator over the other two legs directly to the transformer feeding the lamps at x, regardless of whether any or all the switches were closed from the 1200-volt bus bars to the step-up transformers.—Editor.]

Municipal Inspection.

To the Editor of American Electrician:

Sir.—In your edition of January, 1900, I read an article entitled "Municipal Inspection" which to some wireworkers and contractors is a lesson—a free lesson.

Mr. Inspector, a word to you and your profession. Are you the "cure all" whose advent was hailed by delight on the part of many? Now, I candidly think not, my reason is, you do not well attend your own business and you do interfere with the business of others. Don't misunderstand me, I have no ill-feeling against any inspector. My fortune has been to meet only with intelligent inspectors, and being intelligent men I sought to cultivate their acquaintance and friendship.

First—You interfere with the business of the electrical engineer who earns his livelihood by giving such information as you distribute gratis, and, my dear inspector, you often go and look the matter up which, is indeed, very wrong.

Secondly—You put yourself in the way of legitimate contractors, men whose work is their pride and whose pride is their work. They find in you the stumbling block which makes their work lessen and consequently raises the price of the remainder, which in turn serve to thin out, this cycle indefinitely repeating itself. You may ask how? The answer is the public depend on you to see that their work is done right. They know not your limits, consequently you have none; your word "allright" must cover all. They feel that now they have a competent man to inspect they need not "pay fancy prices," as they term it. Here is just where the cheap man gets all the work; the price is low and it is inspected.

This is not the greatest evil; the evil exists when you take owners as school boys and go through the whole work, dwelling on the good and the bad and carefully explain this and that. There's the rub. You properly say that you have nothing to do with the drop, neither have you anything to do with the dummy outlet nor the number of switches. Connect your bridge and test your insulation and if it does not come up to the standard reject and condemn it. I claim you have no more right to determine, locate or describe mechanical faults than the owner of the job has to expect you to find the leaks your galvanometer may indicate. When once your readings are correct you should, in order to give a first-class inspection, make an examination of apparatus, and if it be defective, condemn it and leave a copy of rules (which should be returned or paid for). If you are called upon to give information refer the man who wants something for nothing to the city directory, where he may find the names of engineers who make a living by consultation—at least this is their honest purpose.

Lastly, Mr. Inspector, if you have any spare time for details seek audiences with prospective builders (don't waste any time trying to teach architects), dwell on the importance of using iron-armored conduits, not only from the standpoint of safety but also that of accessibility; explain the life of the rubber we get on wire now, and in ninety cases of ninety-one your words will have an effect which in ten years will astonish your profession.

A combined effort on the part of inspectors generally to accomplish a given purpose will meet with undoubted success, no matter what the opposition may be.

In this city we have no inspector with the exception that one of the lighting companies (i. e., the one) has an inspector who looks out for the interests of the company. We have no rules of any sort, in fact there is perfect anarchy as far as electric construction is concerned.

Yet the work is fairly done and we have but few "push button" electricians. The system generally employed is the detestable "bushing system." I can imagine the contrast of our city wired with its hundred thousand incandescents protected by iron conduits (instead of rats' and mice nests, water-logged rafters, twentieth grade of what was rubber once).

M. A. de Lew.

Sacramento, Cal.

The Decadence of the Series Arc Machine in the Electrical Journals.

To the Editor of American Electrician:

Sir:—In the enthusiasm and excitement of polyphase current developments the good, old-fashioned direct-current arc dynamos receive scant attention now-a-days. In all the articles that are written and published and extensions of central stations that are announced the erstwhile mainstay of electrical industry—the series arc machine—either does not enter or takes a remote back seat.

Has the electrical world gone alternating-current mad?

J. S. Burrows.

New York, Feb. 22, 1900.

Compounding a Shunt Generator.

To the Editor of American Electrician:

Sir.—Very frequently some of your readers who are in the repair business are called upon to compound a shunt generator. From my experience, I think that the best way to proceed is as follows: First, belt the generator to some source of power and run it at no load, normal voltage and at the speed for which it was designed. Connect in series with the field an ammeter that will read to hundredths and record its field strength and run a lamp cord from the brushes to a voltmeter to record the voltage. Suppose this field strength is 2.62 amperes and the voltage is 110. Next run the generator at full load, normal voltage and at same speed for which it was designed and record similar readings. If the machine is small, a bank of incandescent lamps will serve as load, but if it is rather large, a water rheostat will be more convenient. Suppose the field strength this time is 4.62 amperes and voltage 110, or normal.

The number of turns already on the shunt winding is supposed to be known, but if not it can be ascertained from the manufacturer of the machine. We will suppose the number to be 960 turns. Hence the necessary magneto-motive force in ampere turns to carry the load is $(4.62 - 2.62)\ 960 = 1920$. Taking the full load on the generator to be 130 amperes, the number of turns on the series winding to exactly compound the machine would be $1920 \div 130 = 14.7$.

If a generator turns out to be under-compounded, the only remedy is to rewind the series field, but if it is over-compounded, the defect is easily remedied by shunting some of the current from the series winding. Hence we will pursue the latter method, and to be sure that it is overcompounded, we will add about two more turns, making a total of 16.5 turns. After putting on this winding run the generator at full load normal voltage, keeping its shunt field strength the same that it was for no load, normal voltage, and seperately excite its series field from another generator, using a rheostat of high resistance in its field. By adjusting this rheostat, enough current may be sent through the series field of machine to be compounded to keep the voltage normal when full load is thrown on. The amount of drop across the series winding will have to be known subsequently, so a low reading voltmeter must be used to record it. In this case suppose it to be 1.38 volts. Suppose the current required in this series field to retain normal voltage to be 116 amperes.

If this winding was, when completed, connected in series with the armature, 14 amperes too much would pass through the series field; hence a German-silver shunt must be connected in multiple with this winding to take that portion of the current from it. Now cut several strips of German silver of convenient width and three or four feet long; place them together in parallel and send the required amount of 14 amperes through it, and by moving the ends of the lamp cord, run to a low reading voltmeter, along on the shunt until you have the same drop (1.38 volts) that was gotten across the series winding when separately excited, the correct length of shunt is obtained. Thermometers are placed on this shunt, while the current is being passed through it for several minutes, in order to see if it does not get too warm or to prove that it has the proper carrying capacity. The series field now being wound and the shunt made, all that is necessary is to connect the machine up properly and it is ready to run as a compound generator.

G. J. Reynolds.

Nashville, Tenn.

Electrical Catechism

409. What is the "metric" or "C. G. S." system of units?

This is a system worked out in Paris about a hundred years ago and gradually adopted by scientists in all parts of the world. It is legalized, but not made compulsory, by Congress. The name "C. G. S." is an abbreviation of "centimeter-gram-second," indicating the principal units of the system.

410. Why do so many electrical engineers use the metric system?

Because its units are regularly related on the decimal system, so that it is easy to pass from one unit to another without so many and tedious calculations as are necessary in the English system. The electrical units are derived from the "C. G. S." units, and for the sake of uniformity as well as convenience, electrical engineers use the same system as other scientists. On account of the common use of the English pound and inch in the shops, it is frequently necessary to use the English units in giving dimensions, so that both systems are used together.

411. What is the centimeter?

The centimeter is the unit of length and is intended to be the one thousand-millionth part of the distance from the equator to the pole of the earth. Practically, it is the one-hundredth part of the distance between two parallel lines ruled on a bar of platinum, which is carefully preserved in the Archives of Paris. The word "meter" is derived from French, Latin and Greek words, meaning "measure."

412. What are the other units of length used in the metric system?

The millimeter is one-tenth part of the centimeter. The meter is one hundred centimeters. The kilometer is one thousand meters.

413. What is the English equivalent of the centimeter?

The centimeter equals 0.393704 inch, or one inch equals about 2.5 centimeters. A meter is about 39.4 inches. A kilometer is about ⅝ mile. A square centimeter is 0.155 square inch, and a square inch equals 6.452 square inches.

414. What is the gram?

The gram is the unit of weight; this is the weight of a cubic centimeter of water at 4 degrees Centigrade, or 39.2 degrees Fahrenheit, which is the temperature of greatest density. The gram, or gramme, takes its name from the French word *gramme*, which is derived from the Latin and the Greek *gramma*, meaning "a small weight."

415. What is the English equivalent of the gram?

The gram equals 15.432 grains, or

0.03527 ounce, or 0.002204 pound, avoirdupois. The kilogram (1,000 grams) equals about 2.2 pounds. One ounce avoirdupois equals 28.35 grams. One pound avoirdupois equals 0.4536 kilogram or 453.6 grams.

416. What is the second?

The second is the unit of time and is the same in the metric and English systems. It is the time of a single swing of a pendulum one meter long at the sea level at 45 degrees latitude, and is 1-86400 of the mean time from noon to noon.

417. What is the C. G. S. unit of force?

The dyne (derived from a Greek word meaning "force") is the metric or C. G. S. unit of force. It is the force which, when acting for one second on a mass of one gram, gives it a velocity of one centimeter per second. The earth attracts every particle at its surface with a force of 978 to 983 dynes.

418. What is the C. G. S. unit of work?

The unit of work and of energy is the erg. It is the work done by a force of one dyne acting through a distance of one centimeter, or, it is the work done in pushing a body through a distance of one centimeter against a force of one dyne. The work of lifting one gram one centimeter is about 980 ergs. (Erg is derived from the Greek word *ergon*, meaning "work.")

419. What is the practical unit of work?

There are two units in each system, the joule and the kilogram-meter in the metric system, and the foot-pound and horse-power-hour in the English. The joule equals 10,000,000 ergs. The kilogram-meter equals about 98,050,000 ergs, depending upon the strength of gravity. The English unit is the foot-pound, which is the work done in lifting one pound one foot against the force of gravity. The horse-power-hour is a larger unit, equal to the work of lifting 1,980,000 foot-pounds. The foot-pound equals about 13,560,000 ergs, or 0.138 kilogram-meter. The kilogram-meter equals 7.233 foot-pounds.

420. What is the difference between work and energy?

Energy may be considered as a cause of which work is the result. Both are measured in the same units, the erg, joule or kilogram-meter in the metric system, or the foot-pound in the English system.

421. What is the difference between work and power?

Power is the rate of doing work. To raise 55 pounds 10 feet would require 550 foot-pounds of energy. To do this in one second would require 550 foot-pound-seconds or one horse-power. To raise the same weight an equal distance in one hour, or 3,600 seconds, would require only 1-3600 horse-power. The same work is done in the two cases, but the power is different, because more time is taken in the second case.

422. What is the metric unit of power?

The unit is the watt, which equals one joule per second. A larger unit is often used, the kilowatt, which equals 1,000 watts. The number of watts equals the product of amperes by volts, or the product of resistance by the current squared. The joule was named after James Prescott Joule (1818 to 1889), an English physicist who did much to verify the law of conservation of energy. The watt was named after James Watt (1736 to 1819), who greatly improved the steam engine, being practically the inventor of the modern engine.

423. What is the English unit of power?

The English unit is the foot-pound-per-second, or foot-pound-per-minute, and equals the power required to raise a weight of one avoirdupois pound one foot per second, or per minute, against the attraction of gravity. The watt equals 0.737 foot-pound per second, or 44.239 foot-pounds per minute. The horse-power is frequently used as a unit, being the power required to do the work at the rate of 550 foot-pounds per second, or 33,000 foot pounds per minute.

424. How much power is required to raise a weight of 20,000 pounds a distance of 20 feet?

It depends upon the time in which it is to be done. A small boy could raise it with a differential pulley of sufficient multiplying power; a team of horses could raise it in a much shorter time. The power increases as the time allowed decreases.

425. What is the relation between watts and horse-power?

The horse-power equals practically 746 watts, or more exactly, 745.941 watts.

426. Is the horse-power equal to the power of one horse?

It was originally intended to be the power that could be continuously exerted by a good strong horse, just as the foot was taken as the average length of men's feet. As engineering and commerce became of more importance, it became necessary to have more definite standards, and so the foot and the pound came to be copies of standards kept by various governments.

427. What is a kilowatt-hour?

This is the unit commonly used in measuring electrical energy. It is the energy represented by one kilowatt operating for one hour. For example, fifty kilowatt-hours might mean fifty kilowatts for one hour, or one kilowatt for fifty hours, or two hundred kilowatts for a quarter-hour.

428. What is the difference between a kilowatt-hour and a horse-power-hour?

The same ratio exists as between the kilowatt and the horse-power. The horse-power represents 746 watts, therefore one horse-power-hour represents 746 watt-hours, or 0.746 kilowatt-hour.

429. What is the relation between heat and work?

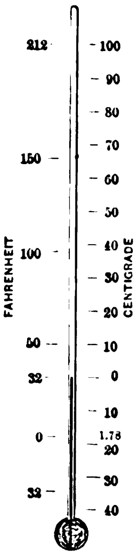
The unit of heat is that quantity required to raise the temperature of one pound of water one degree Fahrenheit at its greatest density. This is called the British Thermal Unit, and is usually referred to as "B. T. U." It has been experimentally determined by Prof. H. A. Rowland that the amount of mechanical work necessary to raise the temperature of a pound of water one degree is practically 778 foot-pounds. Hence 778 foot-pounds is the mechanical equivalent of one B. T. U., or heat unit.

430. What is the metric unit of heat?

The calorie, which is the work required to raise the temperature of one gram of water one degree Centigrade, or 42,000,000 ergs, or 4.2 joules, or 4.2 volt-ampere-seconds, or 4.2 watt-seconds. This is sometimes called a gram-calorie or lesser calorie, to distinguish it from the greater calorie, which is the work done in heating one kilogram of water one degree.

431. What is the difference between the Fahrenheit and Centigrade thermometers?

Fahrenheit (a German physicist living from 1686 to 1736) took what he supposed was the lowest possible degree of cold and called it zero. He then divided the range between the freezing and boiling points of water at ordinary atmospheric pressure into 180 equal parts and continued the scale to the zero point, which made the freezing point come at 32 degrees. The Centigrade scale was worked out in 1741 by Prof. Anders Celsius, of Upsala, Sweden, who divided the range between freezing and boiling into 100 equal parts. The Centigrade thermometer is commonly used in scientific work, while the Fahrenheit scale is more often used by engineers who are accustomed to the English scales and units.



432. How can degrees be changed from one scale to the other?

To reduce degrees Fahrenheit to degrees Centigrade, subtract 32 and multiply by 5-9. To reduce degrees Centigrade to degrees Fahrenheit, multiply by 9-5 and add 32 degrees.

433. What systems of electrical units are in use?

The electrostatic and the electromagnetic units. The former system is derived from considering as a unit the amount of static electricity that will repel or attract an equal amount one centimeter away with a force of one dyne. The electromagnetic units are derived by considering as a unit magnetic pole one that will attract or repel a similar pole at a distance of one centimeter with a force of one dyne.

Queries and Answers

(1.) If a set of storage batteries were placed between a dynamo and motor, and a sudden load were thrown on the motor, would the storage batteries act as a check against the sudden load coming upon the dynamo; in other words, would the batteries prevent the sudden strain upon the dynamo? (2.) What percentage of the power would a storage battery give out after being fully charged, that is, what would be the loss in power that the batteries would absorb in charging and discharging? (3.) Would the complete discharging of a battery (storage) injure it, and how can I tell when one is fully charged and when it is completely discharged?
F. W. Q.

(1.) The storage batteries would only act as a check provided the voltage at that part of the circuit to which they are connected falls with increase of load. If the battery is placed near the dynamo, and the latter is over-compounded, its voltage will rise when the load increases, which will tend to make the storage battery absorb instead of give out current at such times thus increasing the local fluctuations. If on the other hand the storage battery is placed near the motor end of a long line in which there is considerable fall of potential on heavy loads, then when the load comes on the voltage will drop and the storage battery will tend to discharge when the motor is working and charge when the motor is shut down, thus checking the fluctuations of load on the dynamo. The storage battery can be made to work properly in parallel with an over-compounded dynamo by putting in series with the battery a differential booster so wound as to help discharge the battery when the load of the whole system goes up and to help charge it when the whole load goes down.

(2.) The percentage of the power given to a storage battery which can be obtained again from it varies with the rate of charge and discharge, a greater amount of energy being wasted when the battery is rapidly charged and discharged than when these operations are carried on more slowly. With ordinary normal rates, about 85 per cent. of the power given to the battery can be obtained again.

(3.) The complete discharge of a battery down to zero voltage would quite seriously injure it. A battery is fully charged when it begins to bubble and hiss violently. The voltage constantly rises during charging and constantly falls during discharging, so that you can determine the safe limits of the voltage. You should cease charging at 2.3 volts per cell and not discharge below about 1.87 volts per cell, measured on open circuit.

(1) Will you please give me a good recipe for making etching fluid to mark tools and how to use it? (2) Will you kindly tell me how to tighten the segments in a Siemens & Halske commutator? (3) Will you kindly give me the size of taps and holes for taps and holes for stock of various screw threads from 3/32 to 1 in.?
H. C.

(1) Dilute nitric acid, about one part acid to 3 or 4 parts of water, will work very well. Heat the article to be etched and coat thinly and evenly with wax or thick varnish. With a small scraper—a flatly ground awl or needle, for instance—write or draw in the wax or varnish, the name or design to be etched in the steel. Be sure that every particle of the protective covering is removed where the etching fluid is expected to take hold. Put a little ledge of wax around the protected part and pour on the dilute acid. Try the etching frequently by pouring off the acid and looking at it, or by touching the surface lightly with a painted soft wood stick which will reveal the depth of the etching. Wash thoroughly after etching, to remove all possible traces of acid.

(2) Sometimes it is possible to make repairs by soaking the commutator with thin shellac, after which it is baked in an oven, to evaporate the alcohol, leaving the shellac in the commutator. But to do a first class repair job, the commutator should be taken down, and thicker mica sections put in, or at least some of the sections increased in thickness until all is tight again.

(3) The annexed table gives size of drills and taps for fitting nuts to wire and bolt thrusts.

No.	Diameter About	Standard Threads to the Inch.	Size of Drill to Drill for Tapping.
2	3/32 S	56	No. 53
3	3/32 S	48	" 48
4	7/64 F	36	" 43
5	1/8 F	36	" 42
6	9/64	32	" 33
7	5/32	32	" 31
8	11/64	32	" 28
9	3/16 S	30	" 26
10	3/16 F	24	" 24
11	13/64	24	" 21
12	7/32	24	" 17
13	15/64	22	" 12
14	1/4 S	20	" 6
15	1/4	20	" 5
16	17/64	18	" 3
17	9/32	18	" 2
18	19/64	18	15/64 inch.
19	5/16	18	1/4 "
20	21/64 F	16	17/64 "
22	11/32	16	9/32 "
24	3/8	16	19/64 "
26	25/64	16	5/16 "
28	27/64	14	21/64 "
30	7/16	14	11/32 "

Will you kindly inform me if alternating current can be used on a Rhumkorff coil with the same construction as is used with direct current. If not, kindly state the difference in connections, etc.
E. J.

Alternating current can be used on the same coil, but the make-and-break vibrator will no longer be necessary, as the alternations of the current will set up currents in the high-tension secondary without requiring a make-and-break of the primary, as is necessary when direct currents are used. The coil should be connected the same as for direct current, except that the contact of the vibrator, or make-and-break device, should be screwed up tight so that it cannot break the circuit. The condenser usually used with direct currents is no longer necessary. This condenser is short circuited by screwing up the contact. The spark obtained will not be quite as long as with direct currents owing to the fact that the dying out of the alternating current is not as sudden as the break of the direct current, but the spark will have a much higher frequency. An induction coil wound for battery use will safely stand about 15 or 20 volts of alternating current. It can be connected across a 52-volt secondary with a suitable resistance or inductance in series with it, or its primary can be rewound with a finer wire to take the full voltage without a wasteful resistance.

I have a storage battery for residence lighting at 110 volts, which I want to charge from a trolley line passing the house. Can I connect the battery in series multiple, in order to avoid too rapid charging of each cell, and cut it in series with the overhead trolley wire, so that the section beyond the house will get its power through the battery? There is never more than one car on this section.
G. K.

Yes, but a series-multiple battery is likely to work very poorly. If any one cell is short circuited through disintegration of the plates it will lower the voltage of one of the series-multiple groups. This will prevent the others from absorbing the full charge, the one low-voltage set serving to discharge the others. You had better permanently connect your battery across between the trolley and ground with a resistance in series with it sufficient to give it a slow charging current all day long. You can keep your battery on your lamps all the time with this method of charging, while the other way would compel you to cut it off from the lamps while charging.

Will it hurt to run a composite-wound alternator without the composite brushes on at all?
F. W.

A composite-wound alternator can be run with the composite brushes removed, but in this case its voltage will fall off considerably as the load increases, and it will probably be impossible to maintain normal voltage under full load. The segments of the rectifying commutator should be short circuited, as otherwise the whole for the current from the field is compelled to pass through the rotating shunt, giving considerable drop in this shunt. By short circuiting the commutator this drop is removed. In case the machine does not have a rotating shunt the armature circuit will be open when the brushes are removed unless the commutator is short circuited.

Is there any device that can be used in conjunction with a dynamo used as a sparker for a gasoline engine to furnish current for a 10 or 16-c. p. lamp without injury to the electrodes of the sparker, and can such an arrangement be made to give a steady light to the lamp?
W. B. F.

A dynamo specially built to be used as a gas igniter is too small to serve also for lighting a lamp. While such a dynamo, without any auxiliary devices, would light a small low-voltage high-efficiency battery lamp when running with no other load, the use of the sparker would give a bad flicker to the lamp every time the igniter came into action. A large dynamo, capable of lighting several lamps, could be used to supply both lamps and igniter.

New Apparatus and Appliances

WOOD FOCUSING ARC LAMP.

Fig. 2 shows the mechanism of a series arc lamp just brought out by the Ft. Wayne Electric Works, Ft. Wayne, Ind. The principal feature of the lamp is that the arc is maintained in one position regardless of the consumption of carbons. This, of course, is a familiar feature of searchlights and projector lamps, commonly known as focusing lamps, but it has not been heretofore applied to arc lamps designed for ordinary service. The arc is maintained stationary by the usual expedient of gearing the upper and lower carbon holders together so that the lower one moves up as the upper one descends, the gearing being proportioned with regard to the difference between the rates of consumption of the two carbons. This gearing is shown by Fig. 1.

The large cut shows the general arrangement of the mechanism. The series magnet, which is a small one, strikes the arc, and the shunt magnets control the feed. The rod is controlled by a clutch which has five points of contact, this arrangement being used in order to eliminate uncertainty of feed due to unclean or irregular rod surface.

No cut-out magnet is used. When the shunt-magnet armature is drawn beyond its normal range by reason of sticking mechanism, it closes a set of contacts which short circuit the series magnet, causing its armature to drop. This closes a second set of contacts which cut out the whole lamp. In addition to this cut-out there is an auxiliary one that short circuits the lamp from binding post to binding post when the carbons are consumed.

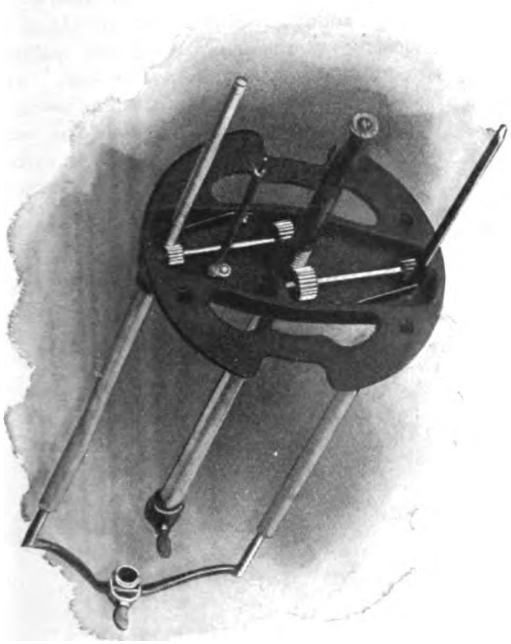


FIG. 1.—GEARING BETWEEN UPPER AND LOWER CARBON HOLDERS OF THE WOOD LAMP.

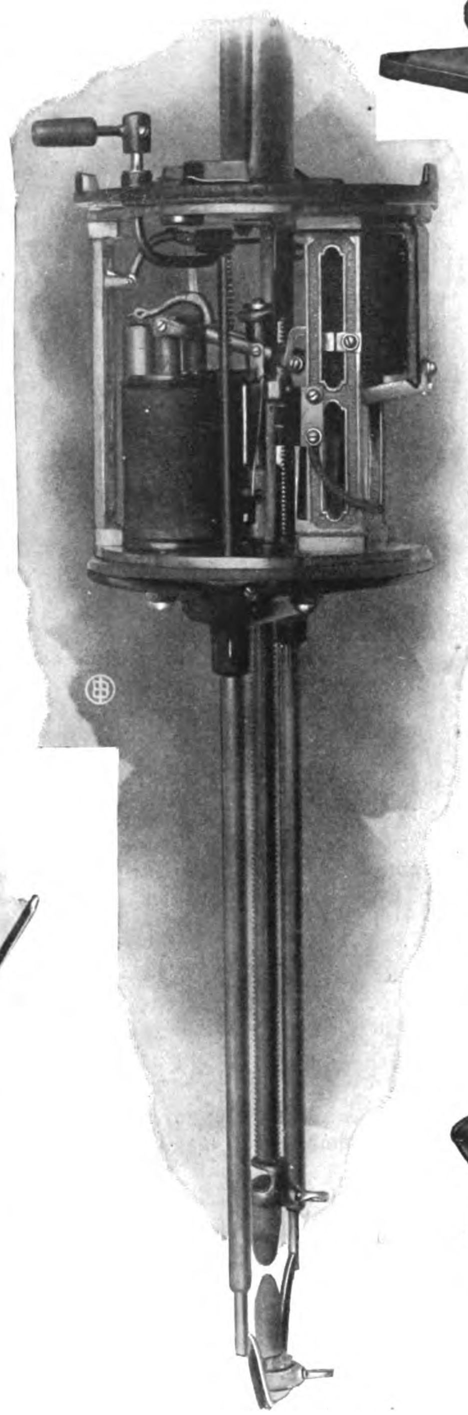


FIG. 2.—WOOD FOCUSING ARC LAMP WITH THE CASING AND GLOBE REMOVED.

C. & C. FOUR-POLE DYNAMOS AND MOTORS.

The C. & C. Electric Company of New York City has developed a new line of dynamos and motors known as Types "F P" and "F P E," one of which is shown by Fig. 3. These are four-pole slow-speed machines of a particularly compact design. The field magnet is a steel casting and each journal yoke is cast in one piece with a ring corresponding in outline to the outline of the field-magnet yoke, making a very smooth finish, as the cut indicates. The two rings are secured to the field-magnet frame by four bolts each. An inspection of the engraving will show that the design of the journal yoke gives a specially stiff construction, the section being practically that of a channel bar. The field-magnet frame and poles are cast in one piece of soft steel and the field coils are wound on metal bobbins. The brushes are of carbon, carried in the well-known reaction type of brush holder used by the company.

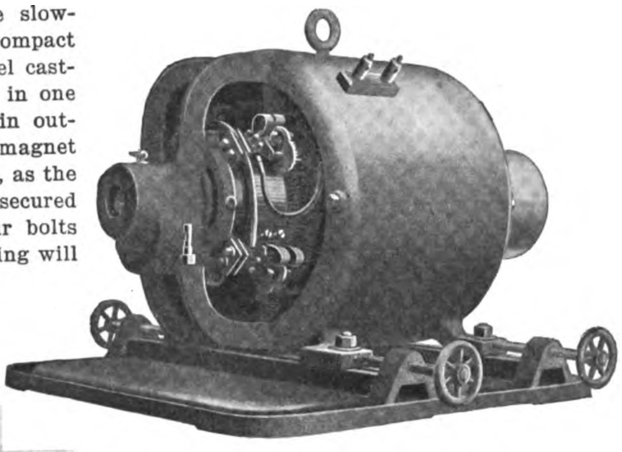


FIG. 3.—TYPE "F P" SEMI-ENCLOSED MOTOR.

The only difference between the "F P" and the "F P E" types is that in the latter the openings around the commutator are closed by shields, effectually protecting the interior of the machine from extraneous interference. These machines are adapted to set on the foundations in the ordinary manner or to be fastened on a wall or suspended from ceiling joists.

The dynamos are built in sizes ranging from 5½ to 35-kw. output; the corresponding motor sizes ranging from 5 to 35 h.p. in the completely-closed type and from 6 to 40 h.p. in the semi-enclosed type. The speeds range from 950 to 650 r.p.m. in the motors and from 1050 to 725 r.p.m. in the dynamos.

VICTOR AUTOMATIC TIME CUT-OUT.

A simple arrangement for opening a circuit at any predetermined hour is being marketed by Vallee Brothers and Company of Philadelphia, Pa., and illustrated by Fig. 4. It consists of an ordinary alarm clock mounted on a base, with the switch to be opened, and so arranged that when the alarm goes off, the hammer strikes a trigger lever. This releases a spring-actuated plunger, which is pushed outward against the cross-bar of the switch, forcing the blades out of the clips, as shown in the illustration. The appliance is known as the Victor automatic time cut-out.

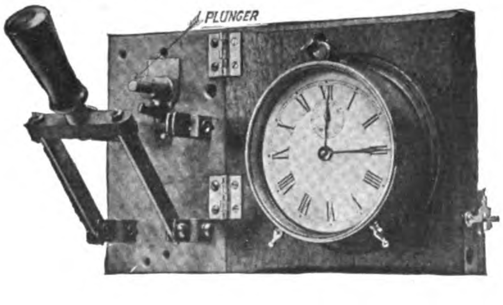


FIG. 4.—AUTOMATIC TIME CUT-OUT.

INTERCOMMUNICATING HOUSE AND FACTORY TELEPHONES.

The telephone shown in the acompanying illustration, Fig. 5, is manufactured by The Chicago Telephone Company, Chicago, Ill., for use in buildings where it is desired to have intercommunication between several telephones without the services of a central operator. The instruments are provided with jacks for as many connections as desired, and the action is entirely automatic. A convenient feature is that the plug can remain where last used; it is not necessary to move the plug at any time except to call another station.

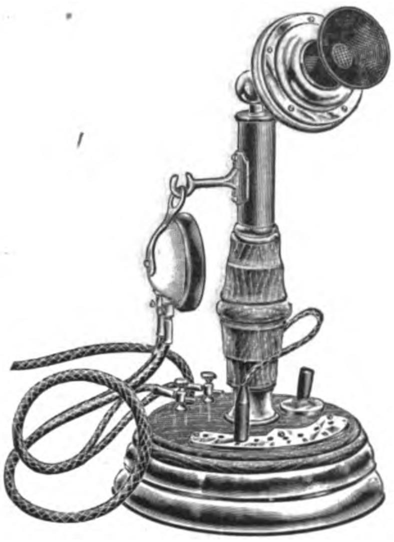


FIG. 5.—DESK TELEPHONE SET.

COMMERCIAL ELECTRIC GENERATING UNIT.

The direct-connected unit illustrated by Fig. 6 is typical of a line of small electric-lighting plants manufactured by the Commercial Electric Company of Indianapolis, Ind. The makers claim for these sets high efficiency and ability to run for long periods with little attention. The engine is provided with an improved Rites governor, giving close regulation, and has a system of sight-feed lubrication. In the dynamo construction the conditions conducive to high efficiency have been carefully studied. The field magnet is built of soft cast steel; the armature is of the slotted-core type, with machine-wound coils, each separately insulated and tested. The field is very "stiff," and this, combined with the use of a large number of armature coils, makes the regulation of the machine unusually good, it is stated, and insures entire freedom from sparking under all loads. These plants are built in sizes from thirty-lights capacity up.

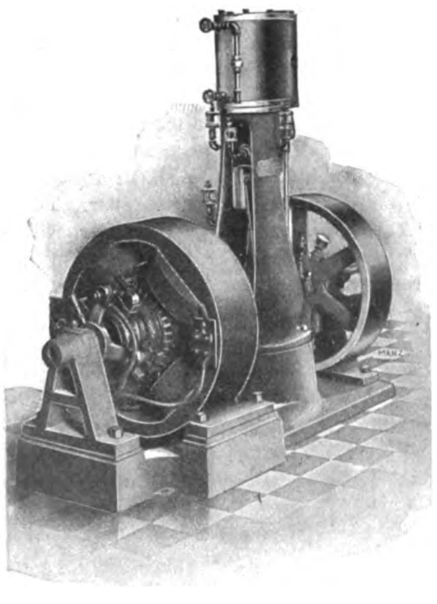


FIG. 6.—COMMERCIAL DIRECT-CONNECTED DYNAMO.

LINCOLN AUTOMOBILE MOTOR.

The standard enclosed motor built by Lincoln Electric Company, of Cleveland, Ohio, for automobile, crane and similar work, is represented by Fig. 7. The field magnet ring or yoke is a steel casting, with the ends flanged inwardly to afford a seat for each journal-yoke flange. The magnet cores are built up of laminations and cast into the magnet yoke.

The standard practice in armature and commutator construction is followed. The controller gives two forward speeds, the maximum being twice the intermediate or slow speed, and one speed backward. Between the stand-still position and the backing contracts are provided contracts for braking electrically, enabling the driver to control the vehicle entirely by means of a single handle.

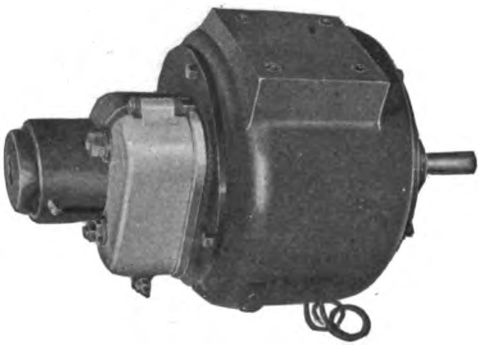


FIG. 7.—LINCOLN AUTOMOBILE MOTOR.

While the motors were designed primarily for automobile service, they have found a sphere of usefulness in crane work, where light weight and abnormal overload ability are important requisites.

A SMALL LIGHTING SET.

The accompanying engraving, Fig. 8, represents a very small generating set, designed primarily for lighting purposes, and built by the B. F. Sturtevant Company of Boston, Mass. The engine cylinder is three inches in diameter by 2½ inches stroke. The valve is of the piston type. All bearings are adjustable and are provided with direct-oiling devices. The generator is capable of 2¼-kw. output. The entire weight of the set is a little over 600 pounds, the engine constituting a little over 40 per cent. of this weight, and the speed is 800 r.p.m.

The field frame is attached directly to the engine frame and placed at floor level, so as to be as stable as possible. This arrangement was facilitated by the adoption of the consequent pole type, giving a four-pole field with only two field coils. As these coils are placed on the horizontal pole pieces, the height of the shaft center is reduced to a minimum. The floor area occupied by this set is only 21 inches by 35 inches, and the height over all is 30 inches. This type of lighting set is built in sizes for supplying 25, 37 and 50 16-c.p. lamps.

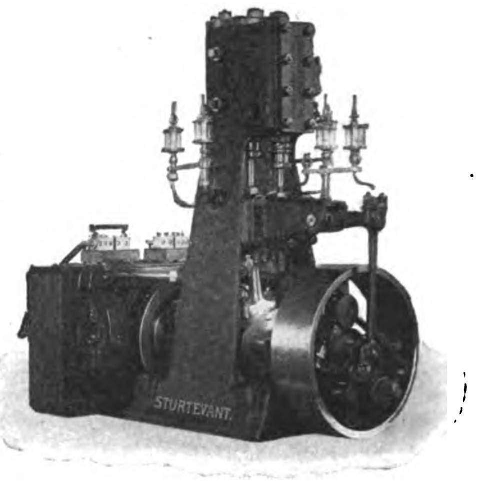


FIG. 8.—STURTEVANT ENGINE AND DYNAMO.

UNIVERSAL JUNCTION BOXES.

In the wiring of buildings for electrical illumination, transmission of power, etc., there are many conditions that necessitate the use of individual junction boxes constructed specially for such emergencies. A new form in this line, and one well adapted to all purposes, is the universal junction box recently brought out by the Sprague Electric Company, and shown in Figs. 9 and 10. This box is so constructed that one, two or more in-leading conduits may be put in place by knocking out one or more tongues, making the requisite openings in the box. The bottom of the box has perforations permitting a wire to be inserted to tie the conduit in place while the work is in progress. This is a very important feature, and saves much time and expense.

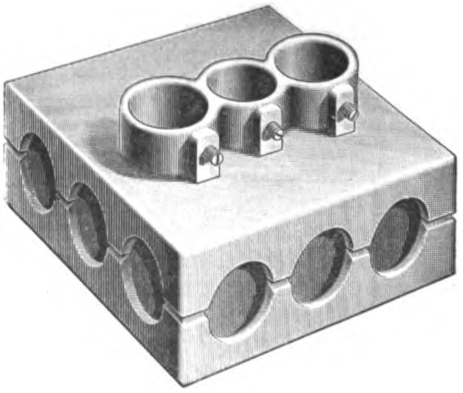


FIG. 9.—UNIVERSAL JUNCTION BOX.

These boxes may be applied either to ceiling or wall, wherever a gas pipe passes through, without the use of ceiling or wall blocks or other means of attachment now ordinarily used. The ceiling box shown in Fig. 10 can be secured to the gas pipe by a set screw.

Fig. 12 illustrates a new type of pipe hook made by the same company, which has the advantage of being secured to the wall or ceiling by a screw or nail, without the danger of being broken by a false blow. In fact, it would be impossible to break it in such a manner.

Fig. 11 shows the new lead bushing and expanding tool which the Sprague Electric Company is now making. The bushing has a thread cast on the outside and can be screwed into the end of the pipe and then expanded by inserting the expanding tool and giving it a few short twists to the right and left, but never turning it completely around.

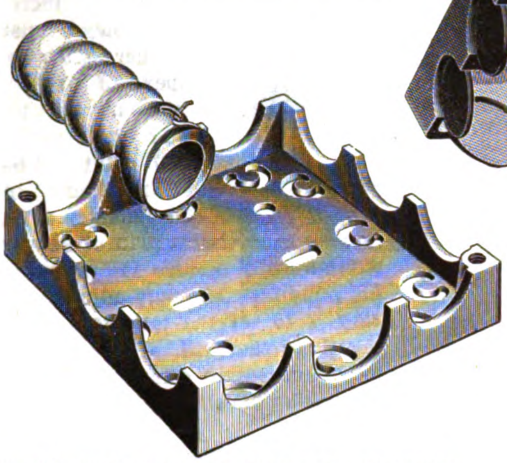
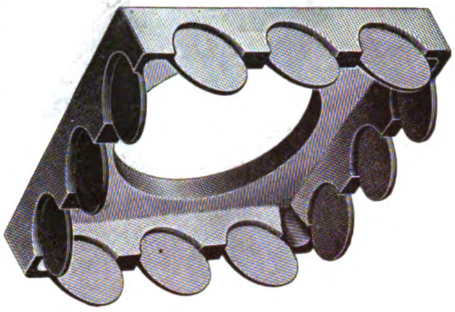



FIG. 10.—UNIVERSAL JUNCTION BOX AND COVER.

A NEW FLUSH SWITCH.

W. T. Pringle of Philadelphia, Pa., has just placed upon the market a new flush switch which is represented by Fig. 15. As the engraving shows, it is a lever switch, in which the usual spring transmission is used in order to secure quick break. The contacts are of the knife-blade type and the mechanism is contained in a brass crib, which relieves the porcelain from all strain. There are no marks to indicate the "on" and "off" positions; when the lever is up the switch is off; when it is down, the switch is on. These switches will fit the standard switch receptacle.

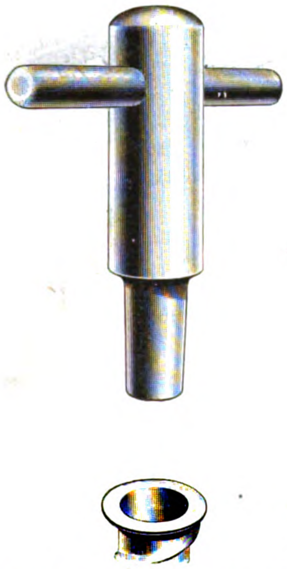


FIG. 11.—LEAD BUSHING AND EXPANDING TOOL.

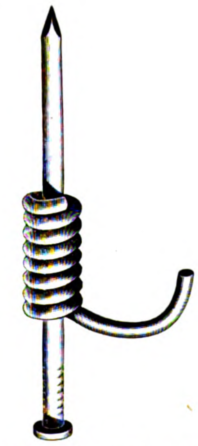


FIG. 12.—PIPE HOOK.

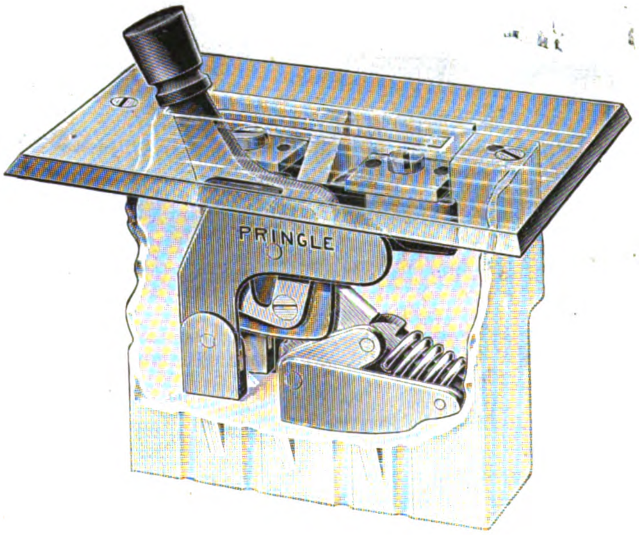


FIG. 15.—PRINGLE FLUSH SWITCH.

STROMBAUGH GUY-LINE ANCHOR.

A convenient appliance for securing the ground end of a guy line is being manufactured by Philip Smith of Sidney, Ohio.

Fig. 13 shows the anchor and Fig. 14 shows an anchor and a wrench such as is used for burying the anchor in the ground. The anchor is nothing more nor less than a shank carrying one complete screw thread about its axis, and it is obvious that if it is sunk in the ground and twisted right-handedly by means of the wrench provided, it will bury itself.

The wrench used has a hollow stem through which the guy wires are led from the anchor outward, as indicated by Fig. 14. The anchors are screwed into the ground to a depth of from 3 to 5 feet, and the manufacturer states that they have been tested severely and none has thus far failed to sustain the severest pull that the guy wire would stand.

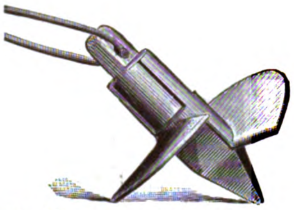


FIG. 13.—GUY-LINE ANCHOR.

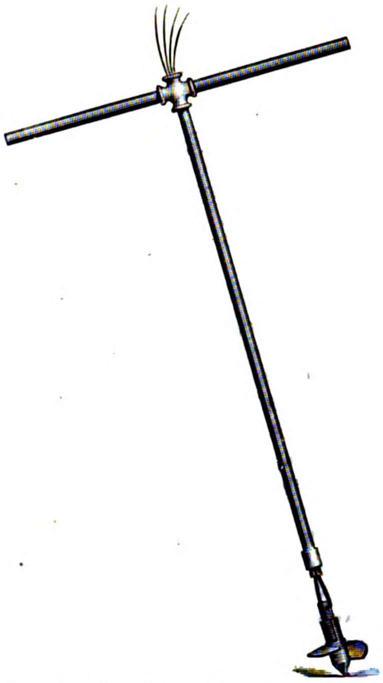


FIG. 14.—ANCHOR AND WRENCH.

A NEW BALL ENGINE WITH AUTOMATIC LUBRICATION.

For a long period a well-governed engine of good make satisfied the users of engines, but the march of progress demands that the up-to-date engine shall not only give close regulation under all changes of load, but shall be automatic in its oiling as well.

To accomplish this end completely, the Ball Engine Company, Erie, Pa., has brought out the engine shown in Fig. 16.

In general appearance this engine is a new departure. Larger proportion and increased strength have been combined with graceful outlines. The same governor and cylinder parts furnished with the standard engine are used in the new type, but valuable features have been added in the design of the other members.

A large pocket in the crank end of the frame is filled with oil to such a level that the shaft discs just touch the surface. While the engine is at rest the whole system of oiling is inoperative, but with the first turns of the flywheels a stream of oil is thrown over the guides and connecting rod boxes and continues as long as the engine is in motion.

A trough around the upper portion of the crank chamber catches a supply of oil and passes it to the main journals, which receive copious lubrication. These bearings are so constructed that, while not a drop of oil reaches the outside of the engine, the engineer may at any time watch the flow of oil or feel the journals.

The guides are of the bored-out type, and by means of a special construction of the bed, the crosshead constantly floats in oil. This feature, together with the large bearing surfaces, practically eliminates wear in these parts.

On each side of the frame, doors are provided, and in the crank end is a hand-hole plate for easy access to the working parts. In addition to these openings the removal of the corrugated hood on top lays the shaft and connecting rod bare for inspection or adjustment.

Across the interior of the engine, between the discs and the guides, are two vertical plates, so placed as to allow the connecting rod to work freely between them. By their construction and position they direct the oil in a straight line to the crosshead, and work a twofold benefit; they limit the amount of oil thrown to the guides to just enough for proper lubrication, and they allow the engine to be run with the side doors removed without danger of a drop of oil reaching the engine room floor. This will be found of great value when taking indicator cards or when watching the internal working of the engine.

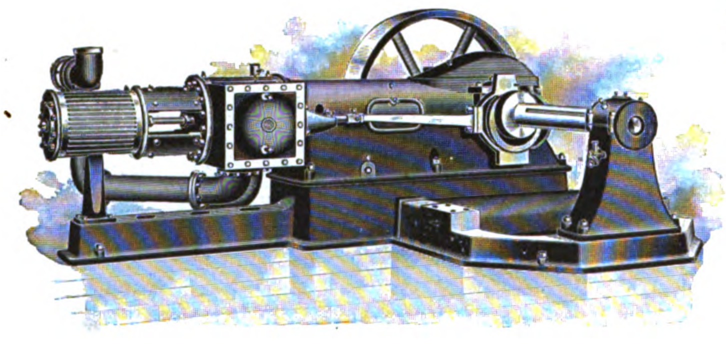


FIG. 16.—NEW ERIE BALL ENGINE.

There is provided a chamber in the cylinder end of the frame which prevents the oil from coming in contact with the heated surfaces of the cylinder head. Openings on each side allow the air to circulate freely and leave the piston stuffing box in full view. This chamber also forms a receptacle for the hot water of condensation from the piston stuffing box.

The construction of the head which connects the two cylinders is worthy of special notice. Two conical shells with tongue projections fit the grooves in the high and low-pressure heads. Bolts passing through the tongues and grooves give to the whole the strength and rigidity of a single casting. This construction not only takes all shearing stress from the bolts but allows the rapid dismembering of the head for examination of either cylinder with the assurance that when reassembled, every part will regain its exact original position.

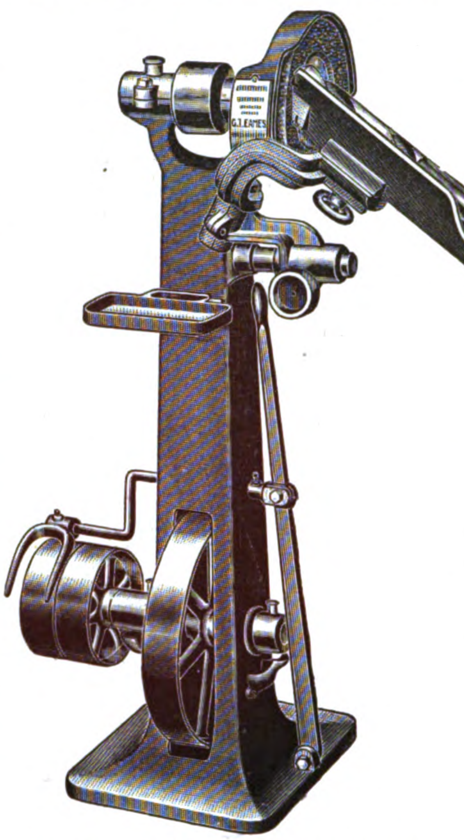


FIG. 17. FULLER TWIST-DRILL GRINDER.

A SIMPLE DRILL GRINDER.

Fig. 17 represents a twist-drill grinder built by the Fuller Manufacturing Company (successors to the G. T. Eames Company) of Kalamazoo, Mich., in which provision is made for enabling a workman to grind a twist drill with mathematical precision without the use of calipering devices, jigs, etc. This provision consists in so mounting the clamp in which the holder swings that the axial line of this pivot, if extended upwardly, would intersect the apex of the "V" holder substantially at the grinding surface of the wheel. Consequently a small drill resting in the bottom of the holder would have its point near this imaginary line, and the cone upon which the cutting end of the drill is ground would be very small, as the circle that it swings on at that point would also be circumscribed.

The angles of the "V" sides of the holder are formed in such relation to this axial line of oscillation that as drills increase in size they must rest further above the apex of the holder. When in position for grinding the drill point will be further ahead of the imaginary intersection of lines as the diameter of the drill increases, so that a drill of any size will automatically assume the proper position for grinding. The only adjustment necessary is to set the tail stock to suit the length of the drill. The holder is never moved except to compensate for wear of the emery wheel.

THE IMPROVED WILLIS PLANIMETER.

The accompanying engraving (Fig. 18) represents an improved form of the Willis planimeter recently brought out by Jas. L. Robertson & Sons, New York City. In the old Willis planimeter the recording wheel was mounted upon and traveled along a glass rod; in the present form the wheel is permanently secured to a steel spindle which is arranged to slide endwise beneath the rollers, R and S. The engraving is nearly self-explanatory. The scale-bar is a triangular one, and the edge of the wheel indicates the reading. There are six scales, any one of three of which can be brought opposite the edge of the wheel by simply revolving the triangular scale-bar. In order to use the other three the scale-bar is removed and turned end for end.

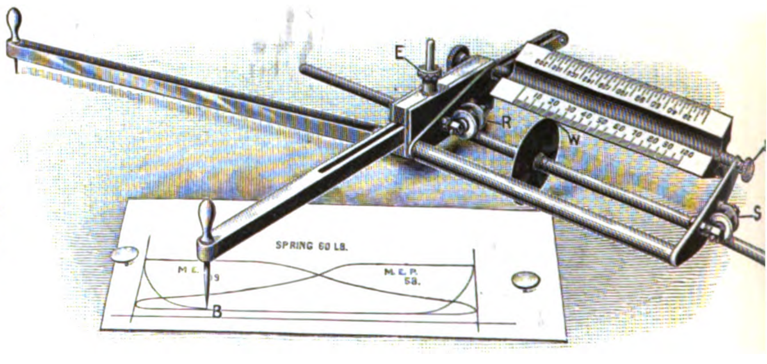


FIG. 18.—IMPROVED WILLIS PLANIMETER.

The arrangement for setting the planimeter to the length of the diagram is the same as that employed in the Lippincott

American Electrician.

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THE WORK OF THE TONAWANDA POWER COMPANY.

Transforming Niagara Power for Motors, Converting it for Railway Use, and Regenerating it for Arc and Incandescent Lighting.

At Tonawanda, 10 miles from Buffalo and 14 miles from Niagara Falls, the transmission line from the falls to Buffalo is tapped and power from it is transformed, converted and regenerated into the various kinds and voltages of current desired for traction, arc and incandescent lighting and distribution to motors. There is no electrical generating plant driven by steam power in Tonawanda or North Tonawanda either for street railway or central station loads. The work at Tonawanda is carried on by the Tonawanda Power Company, which is closely allied financially with the other Niagara power interests, such as the Niagara Falls Power Company and the Cataract Power and Conduit Company. The Tonawanda Power Company consists of the consolidation of the Tonawanda Light and Power Company, which formerly operated a steam-driven central station of the usual type in Tonawanda, and the Tonawanda Cataract Power Company, which previous to the consolidation was formed for advancing the Niagara power interests in Tonawanda. The consolidated company has erected a transforming station immediately beside the right of way of the transmission line at a convenient point in North Tonawanda about a mile east of the business center and just a short distance south of the branch of the Erie running to Lockport, which branch is operated by electric power from this transforming station.

The general scope of the Tonawanda Power Company's operations is similar to that of the Cataract Power and Conduit Company of Buffalo as outlined in the January issue of the American Electrician. That is, the company transforms power as received from the high-tension transmission line to a lower voltage and distributes it to consumers desiring 25-cycle alternating current. The Tonawanda Power Company, however, goes further and converts power into direct current, which it delivers to the International Traction Company for its street and interurban railways in the neighborhood, and also regenerates power by means of motor generators into forms suitable for arc and incandescent lighting, which it distributes and delivers just as does any central station corporation.

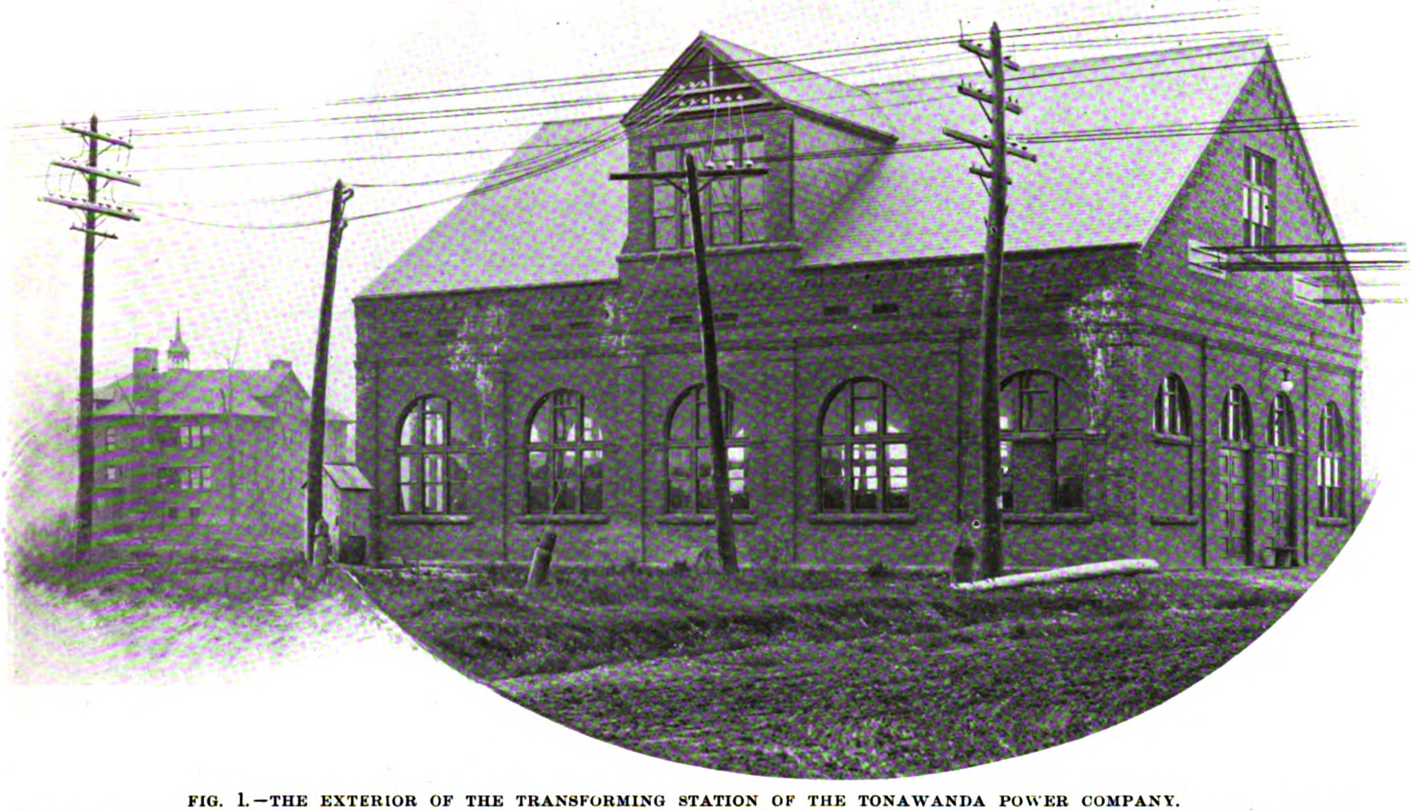

FIG. 1.—THE EXTERIOR OF THE TRANSFORMING STATION OF THE TONAWANDA POWER COMPANY.
The six upper wires on the poles in the foreground are the two three-phase lines running from Niagara on the right toward Buffalo on the left. Taps from these pass into the left-hand side of the gable. The lower three wires passing out to the right form the 11,000-volt branch line to Lockport. The heavy wires passing out from the right-hand end of the building are the railway feeders, and the lighter wires beyond them are the central station lines.

The transforming station, the exterior of which is illustrated in Fig. 1, is a brick structure about 60 feet square, with architectural pretensions somewhat

above those of the average central station, as the picture shows. The main floor is divided by a row of steel columns into two bays, one of which, see Fig. 9, is occupied by the transformers for all purposes and the rotary converters for traction purposes. The other bay, see Fig. 10, is intended to contain the motor generators for supplying the arc and incandescent lighting circuits. The arrangement of the machines is shown in the floor plan, Fig. 2. The construction is fireproof, the floor being of concrete with a cement finish, with ample provision for the wire runs in the form of iron-covered subways and cross-connecting McRoy ducts and six-inch sewer pipes between these subways and the pits under the machines. The main operating room is not carried up into the roof frames, but is ceiled over above the cranes, which serve the two bays, giving a second floor. This upper story, which is a sort of attic occupying the four gables of the roof, see Figs. 3 and 5, contains the high-tension switchboards, circuit breakers, lightning arresters, and other apparatus which is cut into or connected with the high-tension lines before they reach the step-down transformers on the floor below.

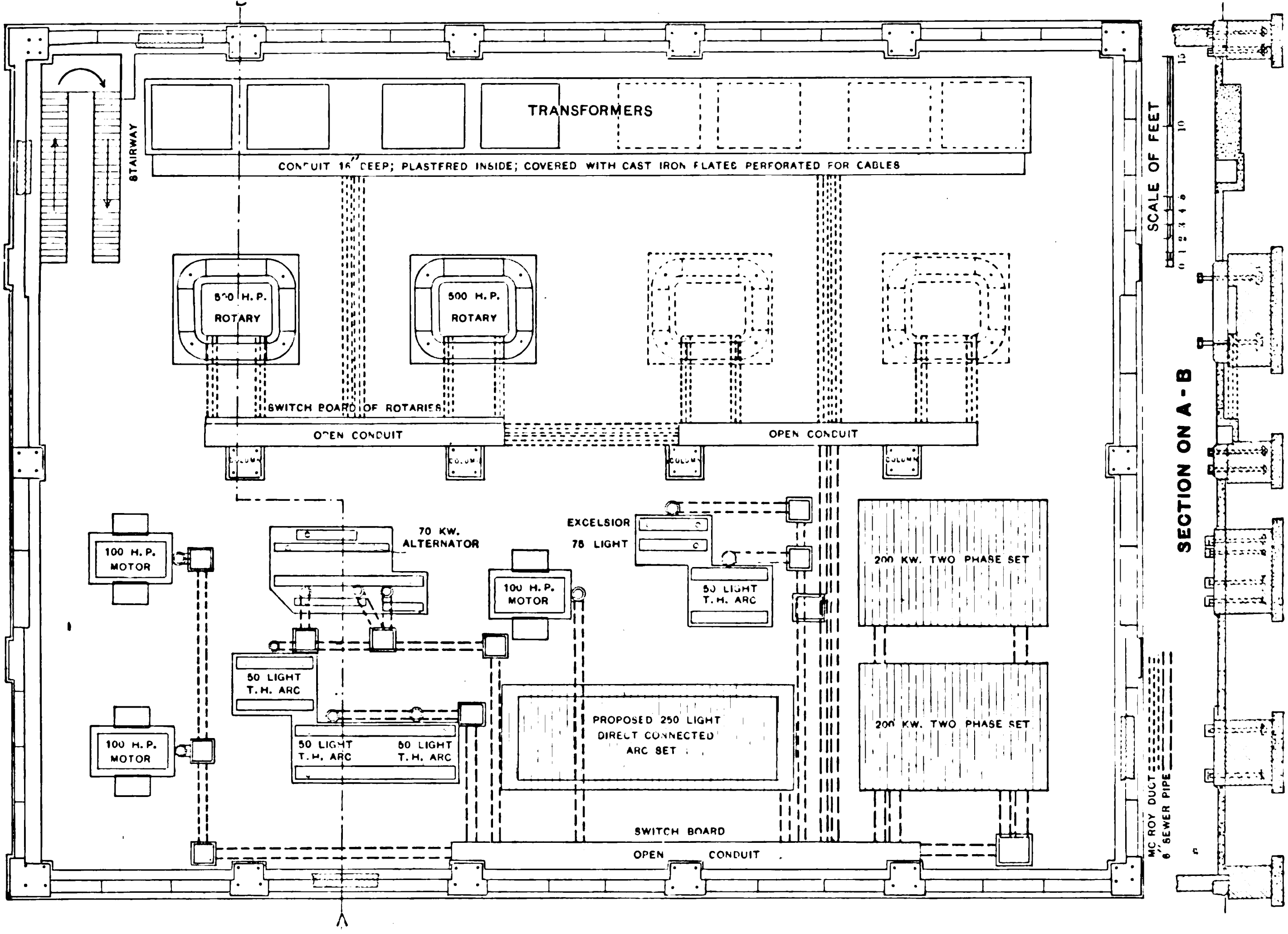
TRANSFORMERS
CONDUIT 16" DEEP; PLASTERED INSIDE; COVERED WITH CAST IRON PLATES PERFORATED FOR CABLES
STAIRWAY
500 H. P. ROTARY
500 H. P. ROTARY
SWITCH BOARD OF ROTARIES
OPEN CONDUIT
OPEN CONDUIT
COLUMN
70 KW. ALTERNATOR
EXCELSIOR 75 LIGHT
100 H. P. MOTOR
100 H. P. MOTOR
100 H. P. MOTOR
50 LIGHT T. H. ARC
50 LIGHT T. H. ARC
50 LIGHT T. H. ARC
50 LIGHT T. H. ARC
PROPOSED 250 LIGHT DIRECT CONNECTED ARC SET
200 KW. TWO PHASE SET
200 KW. TWO PHASE SET
SWITCH BOARD
OPEN CONDUIT
SCALE OF FEET
0 1 2 3 4 5 10 15
SECTION ON A-B
MC ROY DUCT
6" SEWER PIPE
A
B

FIG. 2.—A PLAN OF THE STATION, SHOWING THE ARRANGEMENT OF THE WIRE DUCTS UNDER THE FLOOR.

This station is somewhat of a new prop**osition in high-tension work, being a way station tapped into a transmission line and the junction point of a branch transmission line, viz., that running to Lockport. The general arrangement of the circuits is interesting on this account and also on account of the fact that they contain the first equipment of the Westinghouse Company's apparatus for reverse-current and time-element current-breaker protection, the General Electric Company's apparatus for which was outlined in the description of the Niagara-Buffalo transmission line recently described in these columns.**

The station taps both of the three-phase lines running past it from Niagara Falls to Buffalo, these two taps running in through reverse-current circuit-breakers to the high-tension bus bars of the station, indicated in the accompany diagram of the circuits, Fig. 7. By closing one set of these reverse-current breakers the station can be operated from line No. 1, and by closing the other set can be operated from line No. 2, or by closing both sets the station will get its power over both lines in parallel. The reverse-current feature is for use in the last case when a short circuit on one line would interfere with service on both unless the line affected was cut off instantly by a **breaker designed to open it in case the power flows in the wrong direction.***

As soon as they enter the structure the two incoming branches from the two main lines outside the building are both tapped off to a switchboard panel by means of which either one or both of them can be connected to the Lockport line. This arrangement is also shown in the diagram of connections, Fig. 7. The panel is termed a transfer panel, since by means of the switches upon it the Lockport branch can be transferred from one of the Niagara-Buffalo transmission lines to the other. From the transfer panel the Lockport circuit runs to a switch and time-element circuit breaker panel of General Electric manufacture similar to those previously described in these columns. From this panel the Lockport circuit runs out to the Erie tracks, along which it is carried on the poles, which also support the trolley wires.

The transmission line from Tonawanda to Lockport, as well as the sub-station at that point, belong to the International Traction Company, to which power is sold in the 11,000-volt three-phase form at the Tonawanda station. The power is not measured on either an integrating or recording meter, but quite a novel form of instruments has been designed by Mr. P. M. Lincoln for measuring directly the factor of the load curves on which the charges are based. This factor is the aggregate length of time per month during which the load drawn is greater than that contracted for. The instrument, which is illustrated in Fig. 4, might be termed an overload-time meter, or a time-overload meter. It consists of a recording train measuring hours, driven by clock-work, the motion of which is stopped whenever the load is less than the normal amount which the circuit is supposed to take, and is allowed to operate only when there is an overload upon the line. The arrangement of the parts is obvious from a glance at the illustration. Above the clock-work and recording train is an alternating-current magnet with a laminated iron core, the coils of which are in the circuit of one of the series transformers operating the time-element relay of the circuit-breaker panel. Whenever an overload comes upon the line this magnet in the time-overload meter rotates its pivoted armature to such a position that the balance wheel of the clock is free to operate. Whenever the overload is removed the armature rotates back by gravity, catching the escapement of the clock and preventing it from running. The meter thus gives, every time it is read, a record of the number of hours that the line has been overloaded since the last previous reading. Similar meters are in use at other points in the Niagara system; for instance, on the total output bus bar of the 500-volt railway system downstairs in the Tonawanda sub-station. In this meter the magnet consists simply of a loop of iron surrounding the bus bar. This meter measures the overload of direct-current power delivered by the Tonawanda Power Company to the International Traction Company at Tonawanda.

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*The general scheme of this protection was fully explained in the article on the Falls-Buffalo Transmission line in the January issue of the American Electrician.

Referring again to the branches from the Niagara-Buffalo line as indicated in Fig. 7, it will be seen that these run through the choke coils of lightning arresters on their way toward the station circuits. The branches to the Lockport transfer panel are tapped off outside these choke coils so that the station apparatus is protected against any lightning entering over the Lockport branch by the same arresters that take off all lightning coming in from the Falls-Buffalo lines. These arresters are of the Wurts non-arcing metal type, grouped in the usual series-multiple way for high-tension circuits. They appear in the central foreground of the illustration of the upper room of the station, Fig. 3, the lower ends of the panels showing the graphite rod resistances which are cut in between the arresters and ground to prevent the high voltage and high power of these lines from holding an arc across even the many series non-arcing breaks of Wurts arresters. These resistances are such as to limit the dynamo current to five amperes.

From the lightning arresters the two taps run respectively through the two sets of reverse-current circuit breakers, from which they run together in common high-

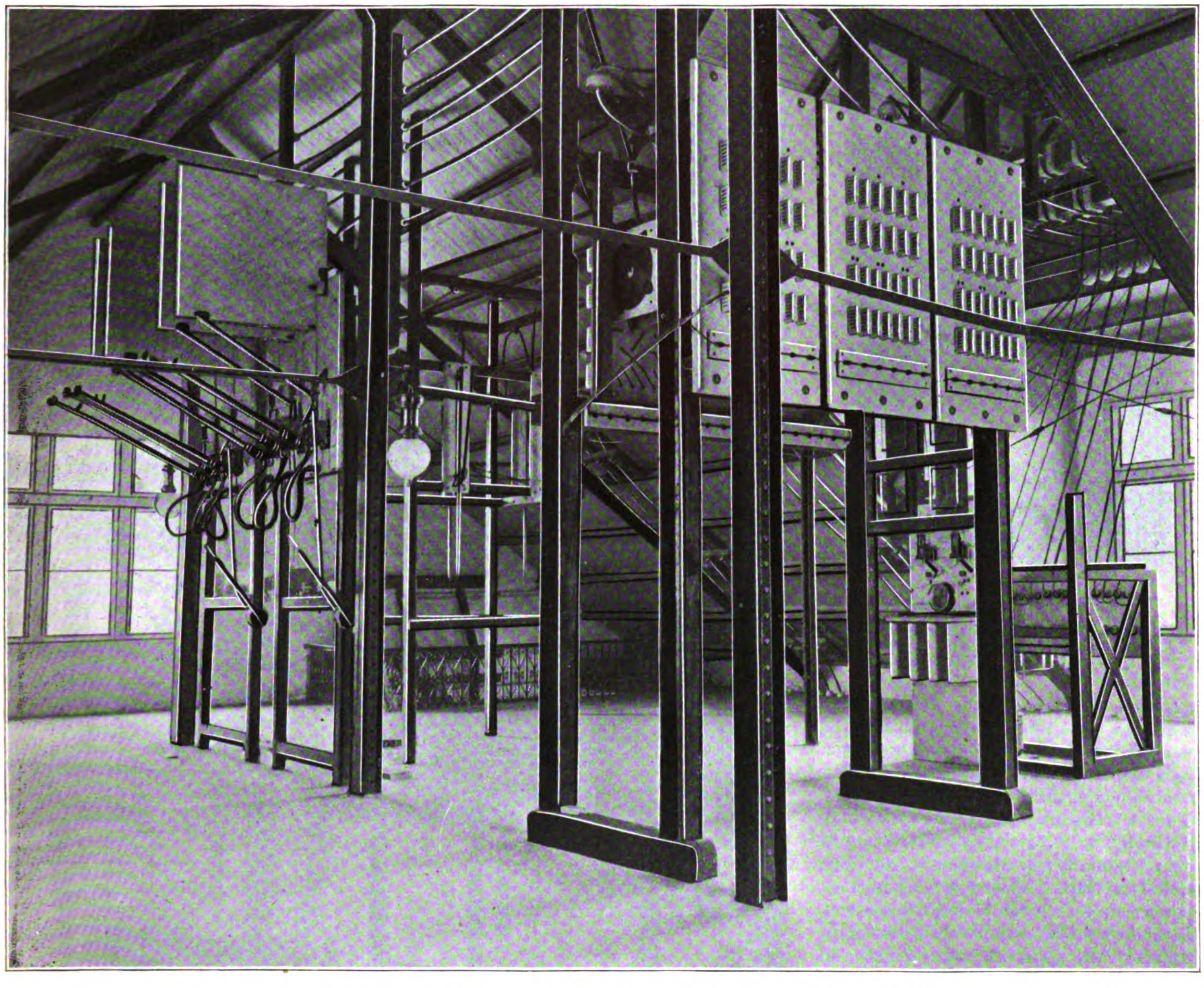


FIG. 3—A GENERAL VIEW OF THE HIGH-TENSION APPARATUS IN THE ATTIC.

To the left are the high-tension circuit-breakers. In the central background are the fuse circuit-breakers. Further to the right are the reactive coils and spark gaps of the lightning arresters; below them are the ground detectors and the time-element circuit-breaker panel and transfer panel of the Lockport line.

tension bus bars which are tapped off through other protective apparatus to the high-tension sides of the step-down transformers. The reverse-current circuit-breakers are made by the Westinghouse Company and differ materially both in construction and in principle of operation from the General Electric reverse-current breakers described previously in these columns. The breakers themselves, which appear in the foreground of Fig. 3, are of the Westinghouse Company's familiar stick type with the long arms and deep barriers necessary for high-tension work, the Westinghouse engineers believing in breaking the arc by sheer length of opening in air rather than shunting the breaker with a fuse, as is done by the General Electric engineers.

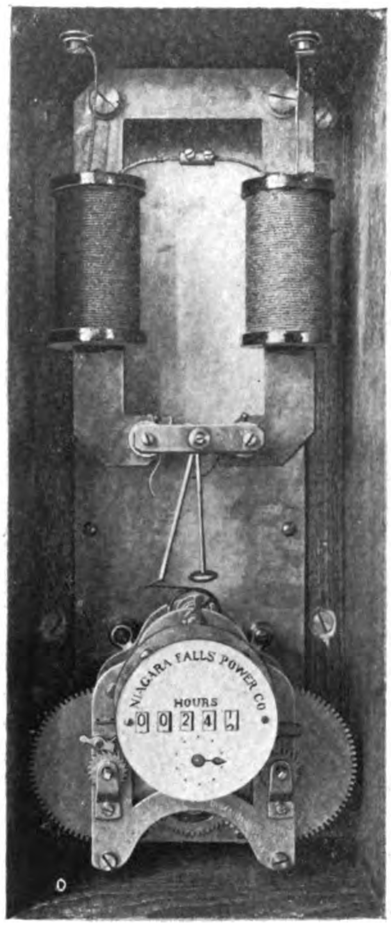


FIG. 4.—THE TIME-OVERLOAD METER.

A clock run the disappearing-figure dial when its escapement is released by an overload upon the line.

The relay system of these reverse-current breakers is much more elaborate than that of the General Electric Company's reverse-current breakers described in the January issue of this paper, being designed to respond to a greater variety of conditions of safety and danger of the circuits. The reverse-current relays themselves in this case are small induction motors of the form used by the Westinghouse Company in its induction wattmeters. The two windings of each of these induction motors are connected respectively with potential and current transformers very much as are the two windings of the direct-current fan motors used for the same purpose by the General Electric Company. The rotatable part of the relay motor—instead of driving a recording train—turns a crank carrying a movable contact which normally rests against a dead back stop, while, if the torque reverses into the other direction, the contact comes against the live front stop, which closes a local circuit, which in turn trips the breakers.

The connections between the series transformers and the relays are quite complex. In the first place, there is only one relay for all three phases of each line to be protected, this relay being a double induction motor with two motors mounted on one vertical shaft just like the double induction motors used by the Westinghouse Company for polyphase meters. The two relays, one for each of the two three-phase lines to be protected, have their circuits interconnected through potential, current and auxiliary transformers much too elaborate and technical for description in these columns. The arrangement is such that if power tends to flow outwardly from the junction point toward line No. 1 the relay of line No. 1 operates, throwing the breakers of line No. 1, but relay No. 2 only holds the firmer against its back stop. On the contrary, if power comes in through line No. 1 and goes out again through line No. 2, relay No. 2 operates, relay No. 1 remaining in its normal position. It will be noticed that in this case there are three circuit-breakers per line, one in each leg of the circuit, although there are only two series transformers. The tripping coils of all three circuit-breakers of one line are wired in parallel to the corresponding relay so that all three are opened simultaneously.

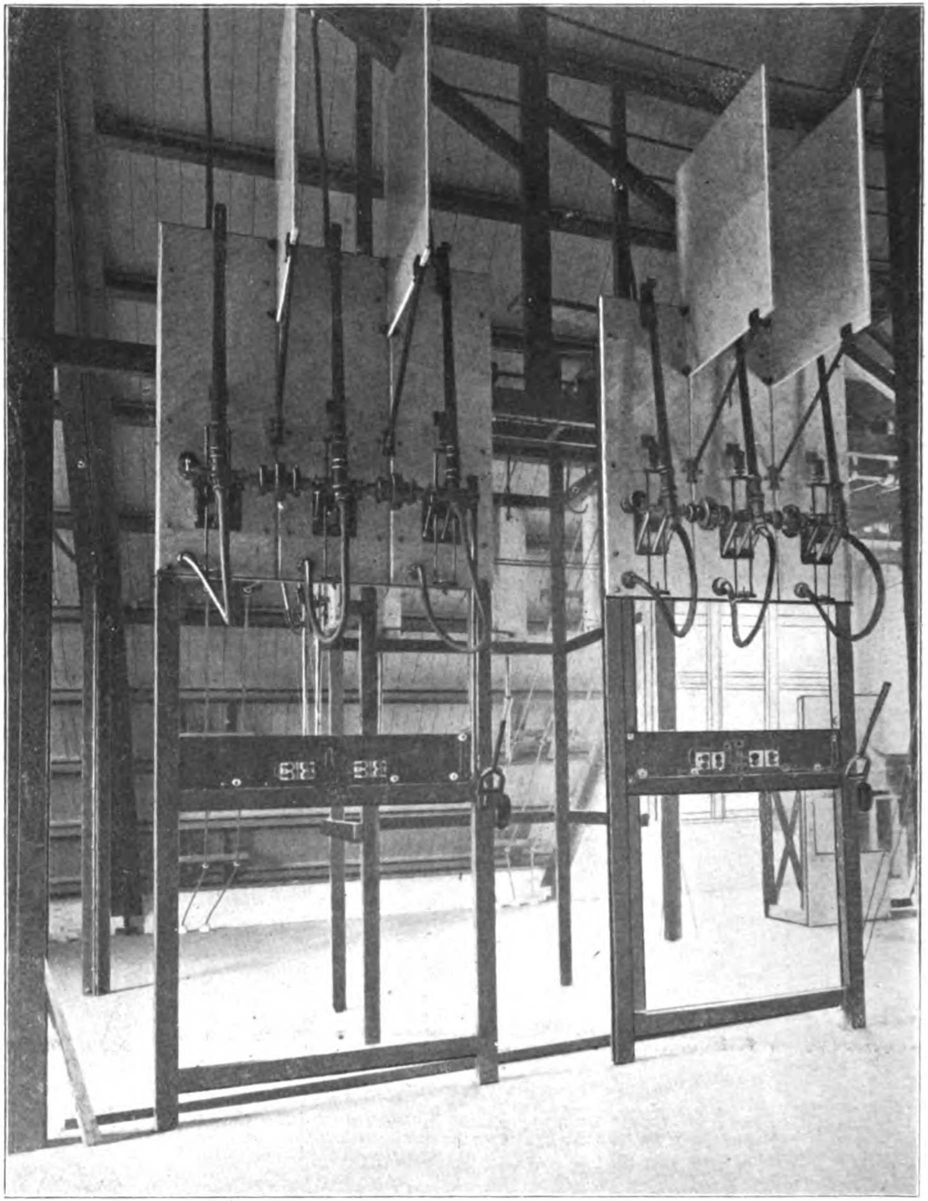


FIG 5.—A VIEW OF THE TWO SETS OF HIGH-TENSION CIRCUIT-BREAKERS USED IN THE TW BRANCHES FROM THE TWO TRANSMISSION LINES TO THE PARALLEL BUS-BARS OF THE STATIONO

These breakers will open under 22,000 volts. They are operated by reverse-current relays.

Taking up the main high-tension circuits again, they run from the high-tension bus bars to the transformers in the station through a novel type of safety device which has been termed a fuse circuit-breaker. Two of these odd devices are shown in Fig. 6, one open and one closed. Each consists fundamentally of an aluminum wire about one foot in length, fastened in carbon clamps and stretched between the upper ends of two long wooden poles. At its lower end the shorter of these poles is hinged to the other and forced by a spring so as to keep the aluminum wire stiffly stretched. The current is led through the aluminum wire, which is designed to fuse at 50 amperes. In case it does melt, the pole is forced outwardly by the spring and is rotated about its pivoted lower end by gravity, giving an opening of about six feet. Current enters and leaves the whole device through jaws which render it removable from the knife contacts on the marble panel on which it is mounted. By grasping the extended lower end of the longer pole the fuse breaker can thus be readily removed for re-fusing. A string is attached to one of the carbon clamps around the aluminum wire, so that the clamp can be opened at any time while the device is in circuit, thus freeing the spring-actuated arm and opening the line.

It will be noticed from the diagram that there are six of these fuse breakers and that they are not connected directly in the legs leading from the high-tension bus bars to the corners of the delta formed by the primary windings, but are connected within this delta, two in each phase; thus each primary winding has in series with it two fuse breakers, one at each end. By this means the blowing of any one of these fuse breakers only throws one of the step-down transformers instead of two, as would be the case were the breakers connected in the usual way into the three legs of the circuit running to the delta. As is well known, when one of three delta-connected transformers is opened, the other two will continue to deliver three-phase currents, while, if two are opened, only one phase remains in service.

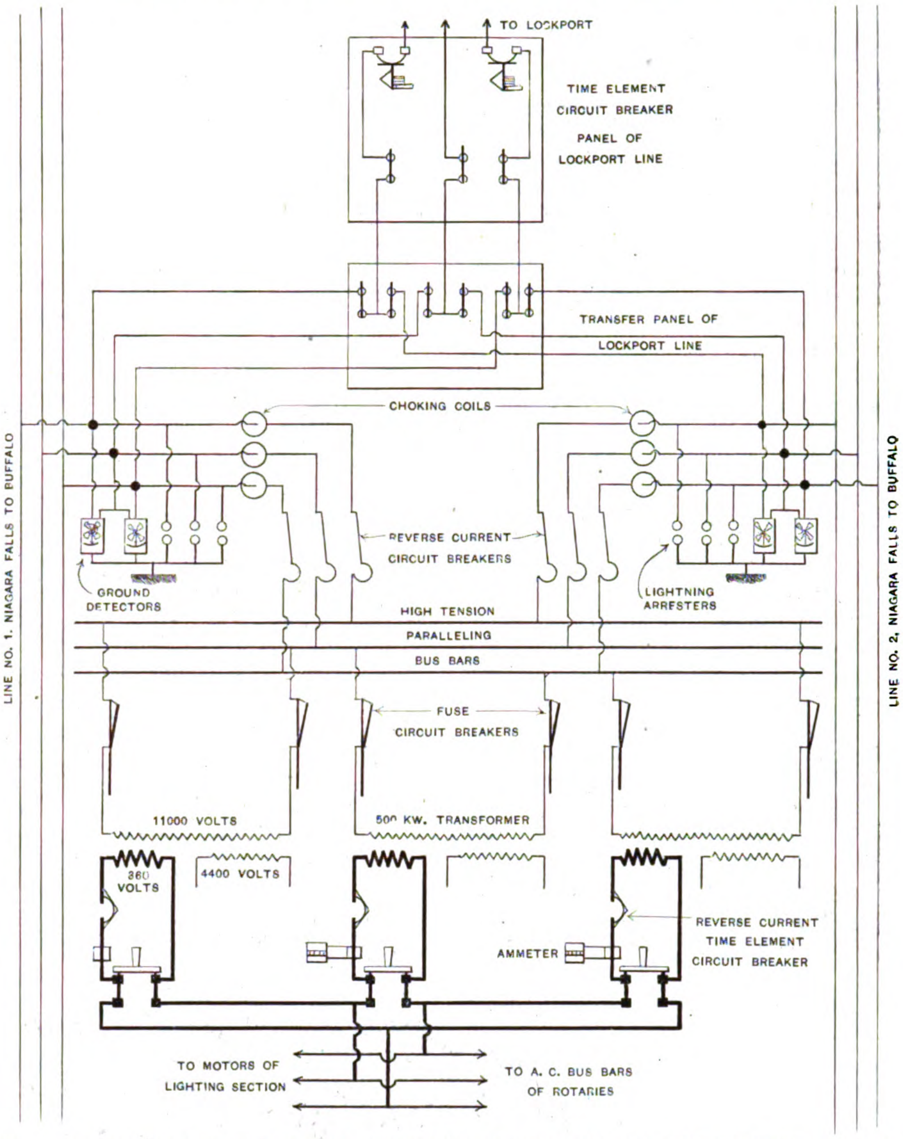

TO LOCKPORT
TIME ELEMENT
CIRCUIT BREAKER
PANEL OF
LOCKPORT LINE
TRANSFER PANEL OF
LOCKPORT LINE
CHOKING COILS
LINE NO. 1, NIAGARA FALLS TO BUFFALO
LINE NO. 2, NIAGARA FALLS TO BUFFALO
REVERSE CURRENT
CIRCUIT BREAKERS
GROUND
DETECTORS
LIGHTNING
ARRESTERS
HIGH TENSION
PARALLELING
BUS BARS
FUSE
CIRCUIT BREAKERS
11000 VOLTS
500 KW. TRANSFORMER
360
VOLTS
4400 VOLTS
AMMETER
REVERSE CURRENT
TIME ELEMENT
CIRCUIT BREAKER
TO MOTORS OF
LIGHTING SECTION
TO A. C. BUS BARS
OF ROTARIES

FIG 7. A DIAGRAM OF THE ALTERNATING-CURRENT CIRCUITS OF THE STATION FROM THE TRANSMISSION LINES TO THE LOW-TENSION BUS-BARS.

This diagram shows the location in the circuit of the reverse-current circuit-breakers, and of the fuse circuit breakers, as well as the connection of switches, ammeters, and circuit-breakers within the secondary deltas.

From these fuse circuit-breakers the line runs downstairs to the step-down transformers. These transformers, which appear to the right in Fig. 9, are of the Westinghouse make and of the oil-insulated self-cooling type. They are four in number, three of them being delta-connected on both primary and secondary sides, the fourth being a spare. There is room provided for four more. Each is rated at 500 kw. The distinguishing peculiarity of these transformers is that each has two entirely independent secondaries, one wound for 4400 volts and the other for 360. These two secondaries are designed to supply simultaneously the two different classes of service to be carried from this station. The higher voltage is intended for the distribution of 25-cycle power to outside consumers, the rather high pressure (for urban distribution) of 4400 volts being adopted on account of the location of the station somewhat out of the center of distribution. The lower pressure of 360 volts is designed for supplying the railway rotaries and the motors of the central station motor generator sets.

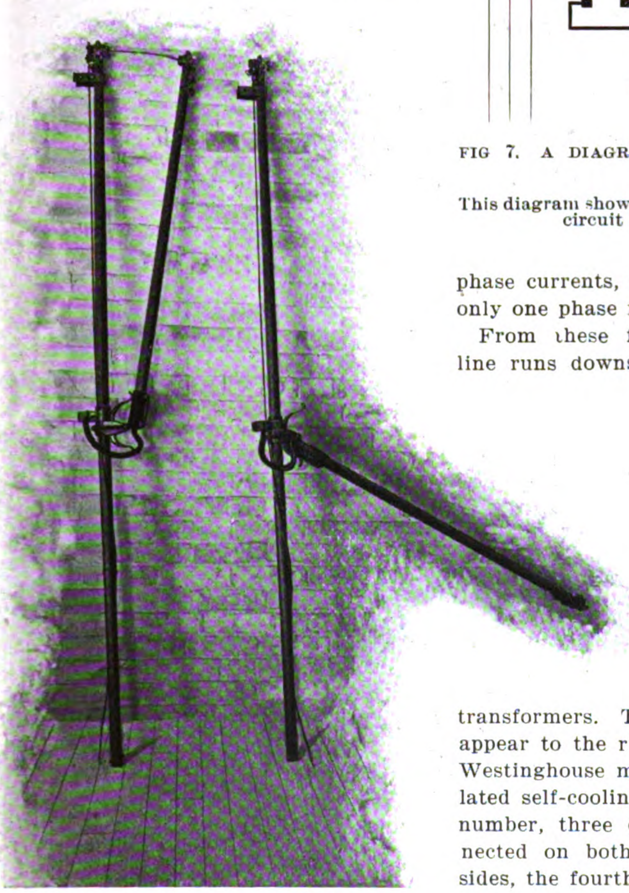


FIG 6 - TWO OF THE FUSE CIRCUIT-BREAKERS REMOVED FROM THEIR CONTACT PANELS.

When the fuse, which is shown in place in the left-hand breaker, is burned, the short arm rotates to the position shown in the right-hand breaker, giving a wide gap in the circuit.

The combination of the two entirely distinct secondaries for separate purposes in one group of transformers is quite a novelty in alternating-current work, but introduces several advantages in cases of this kind. In the first place, it reduces the number of transformers necessary and proportionately increases the rated output of each (thereby reducing the first cost per kilowatt and increasing the efficiency), and in the second place it allows one service to be considerably overloaded if the other is underloaded, as the currents through the primary are the resultant of both loads, and the cool running of one secondary allows the other to run hot without overheating the whole transformer. The two secondaries of each transformer are designed for loads of 250 kw. each when both are loaded. When one is on open curcuit the other is allowed to carry 300 kw.

These transformers are provided with an unusual number of taps from the windings to provide for many different voltages. Fig. 8 shows a diagram of the terminals of primary and secondary windings, and the table immediately below it gives the voltages obtained by connecting into different terminals. This table gives the voltages which would be obtained from the different connections, assuming the same density of magnetization of the transformer iron in all cases.

There are two primary windings which are now connected in parallel, but which may be connected in series with each other when the line voltage is doubled. By means of taps into both ends of each of these windings, one tap cutting off from one end twice as many turns as does the other tap from the other end, the transformer may be suitably connected to obtain its normal density from a line pressure of 11,000, 10,750, 10,500 or 10,250 volts, as the table indicates. By connecting the two primaries in series with each other, voltages just twice all of those above mentioned may be provided for. The low-voltage secondary has provision for regulation by 20 volt steps all the way from 377 volts down to the remarkably low figure—for rotary converter purposes—of 277 volts. This is provided to allow for a considerable rise of primary voltage above even the maximum figures with normal density on the transformer. As 11,000 volts is delivered in Buffalo the pressure rises at Tonawanda at times considerably above this, so that even with all primary turns in circuit the secondary voltage delivered is considerably higher than that given by the table, enough so to bring the voltage across the smallest number of secondary turns between terminals 11 and 12 up above 300 volts, or into the proper range for the three-phase end of the railway rotaries. The transformers are easily able to withstand any increase of voltage which they are likely to have.

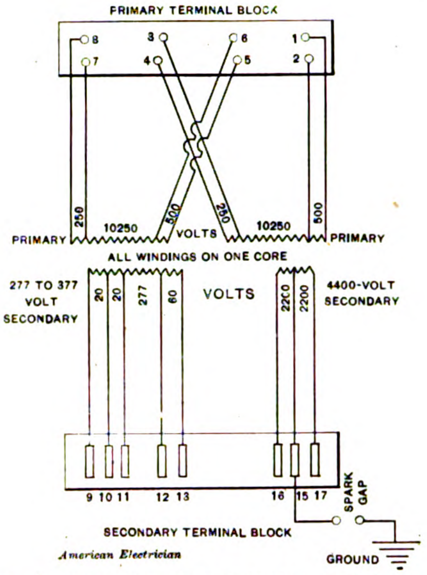


FIG. 8.—THE INTERNAL CONNECTIONS OF THE STEP-DOWN TRANSFORMERS, SHOWING THE METHOD OF VARYING THE RATIO OF TRANSFORMATION.

PRIMARY CONNECTIONS.

For 11,000 volts connect line to 1 and 8, and join 1 to 5 and 8 to 4.

For 10,750 volts connect line to 1 and 7, and join 1 to 5 and 7 to 3.

For 10,500 volts connect line to 2 and 6, and join 2 to 6 and 4 to 8.

For 10,250 volts connect line to 2 and 7, and join 2 to 6 and 3 to 7.

For 22,000 volts connect line to 1 and 8, and join 4 to 5.

For 21,300 volts connect line to 1 and 7, and join 3 to 5.

For 21,000 volts connect line to 2 and 6, and join 4 to 6.

For 20,500 volts connect line to 2 and 7, and join 3 to 6.

SECONDARY CONNECTIONS.

For 4400 volts connect line to 16 and 17.
For 377 volts connect line to 9 and 13.
For 357 volts connect line to 10 and 13.
For 337 volts connect line to 11 and 13.
For 317 volts connect line to 9 and 12.
For 297 volts connect line to 10 and 12.
For 277 volts connect line to 11 and 12.

The spark gap, which is indicated in the same diagram as connected between the middle of the secondary winding and ground, is provided to prevent straining the insulation of the 4400-volt secondary in case of leakage of current from the 11,000 or 22,000-volt primary. The gap is so set that current will jump across when the pressure rises to a value somewhat higher than 4400 volts. If this excessive potential is momentary the gap will simply spark and instantly cease. If, however, the potential is maintained, the sparking will continue, the two cylinders of the gap will be welded together and the secondary will be permanently grounded. Of the three transformers forming the delta, the gap is connected to

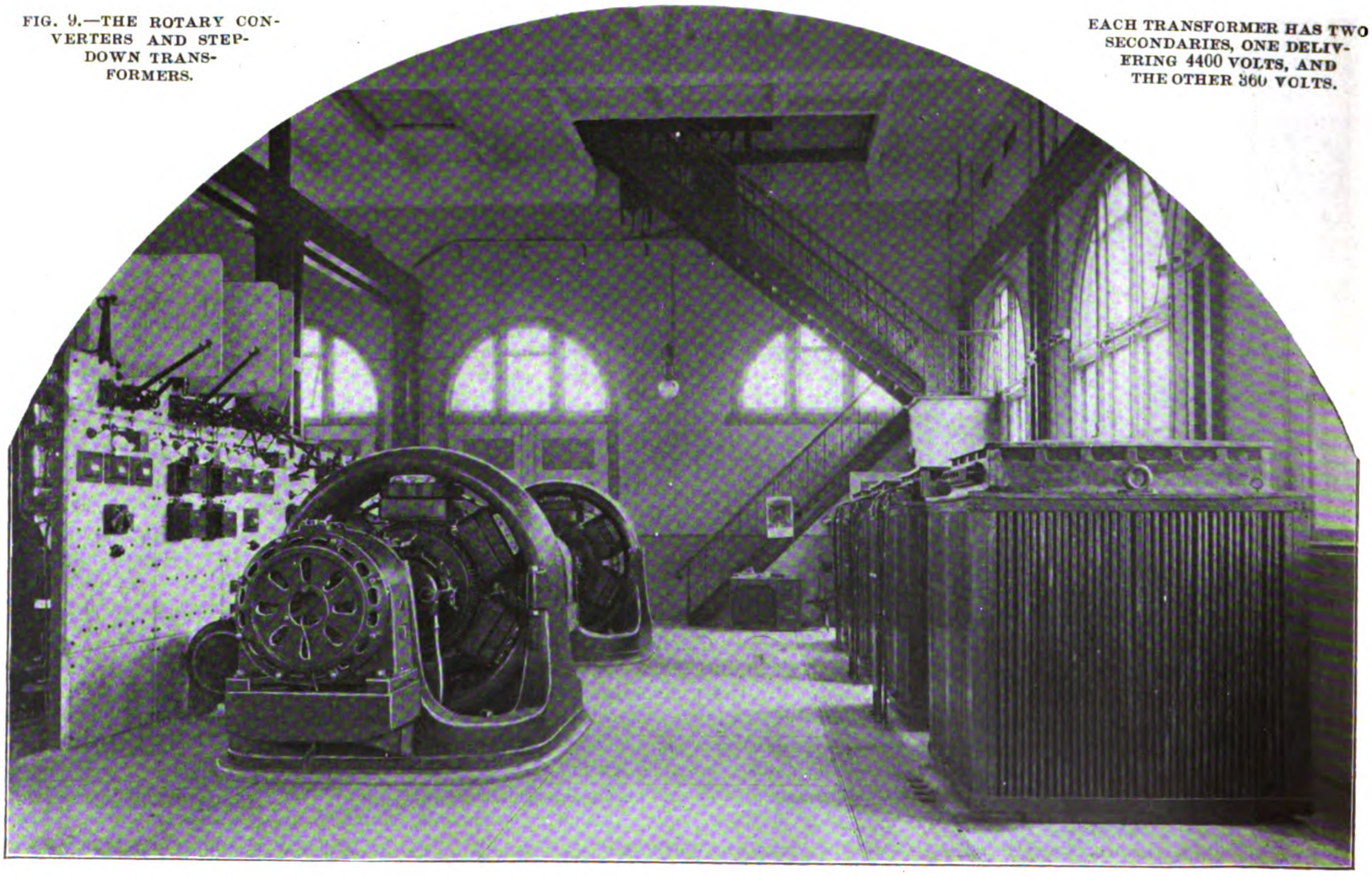


FIG. 9.—THE ROTARY CONVERTERS AND STEP-DOWN TRANSFORMERS.

EACH TRANSFORMER HAS TWO SECONDARIES, ONE DELIVERING 4400 VOLTS, AND THE OTHER 360 VOLTS.

the secondary of one only. A similar spark gap is not used on the 360-volt secondary since this is already grounded through the winding of the rotary converter and its negative brush, which is connected to the railway tracks.

Another peculiarity of these transformers is that their secondaries are only connected in delta through the switches on the switchboard, there being three double-pole switches instead of three single-pole or one triple-pole, to throw them into the bus bars. This arrangement, which is indicated in the main diagram, Fig. 7, allows the three circuit-breakers in the low-tension sides to be included within the delta instead of cut into the three legs running from the corners of the delta to the load. This unique arrangement of the secondary circuit-breakers is provided so that in case there comes a short circuit in one transformer, the fuse breakers in the primary and the reverse-current breakers in the secondaries of this one phase will open, allowing the other two transformers to continue working, delivering three-phase currents. In case the breakers were cut into the legs of the circuit outside of the delta, the opening of one breaker would throw out two transformers, leaving only one at work, delivering only one phase. This would throw a very heavy load upon the one phase remaining at work, while, if two transformers remain in circuit supply motors or rotaries, the apparatus continues working practically as well as with three.

The secondary circuit breakers are of the usual overload type, with time-element attachment, and also have auxiliary tripping coils of the reverse-current relay time-element type, using induction meter motors for relays, but in this case each of the three phases has its own separate single-motor relay. These relays are shown mounted on a panel in Fig. 5. Immediately below each one is a four-part plug and six-part receptacle by means of which the potential element of the relay motor can be reversed to test the operation of the device. Another peculiarity of these relays and their circuits is the fact that each relay is connected with series transformers of the same phase in both the 4400 and the 360-volt secondaries, and in case either reverses, the relay operates, throwing the breaker of the corresponding phase in both outputs. A sort of time element is introduced into these relays by putting on the rotating disc a magnetic brake like that used in the meters. This, however, does not give a time lag independent of the overload, since the greater the overload the stronger is the force acting against the magnetic drag.

In both secondaries the indicating ammeters upon the switchboard are also connected within the deltas, so that each one reads the load upon each phase. The total apparent power is then the sum of the ammeter readings times the voltage, and there is no necessity of a calculation introducing the square root of three to find the power from the ammeter readings. The 4400-volt output is arranged with induction regulators for varying the voltage.

The rotary converters are two in number, rated at 500 h. p. each, both working on the interurban and Tonawanda loads of the International Traction Company. These rotaries are of the Westinghouse construction, as the view of the small induction starting motors in Fig. 9 clearly shows. They are fitted with magnetic oscillators similar to those used in the past on General Electric rotaries and, like them, intended to oscillate the shafts axially and prevent the brushes from wearing tracks or grooves into the commutators and collector rings. The oscillators on these machines are located within the overhanging rotors of the starting motors. The rotaries are compound wound and fitted with an equalizer. They supply the trolley lines over four 600,000 c. m. uninsulated copper cables. All the 500-volt copper is tied together between the Buffalo city line and Lockport and Niagara Falls, thus throwing the rotaries at Tonawanda in parallel with those both at the Falls and Lockport.

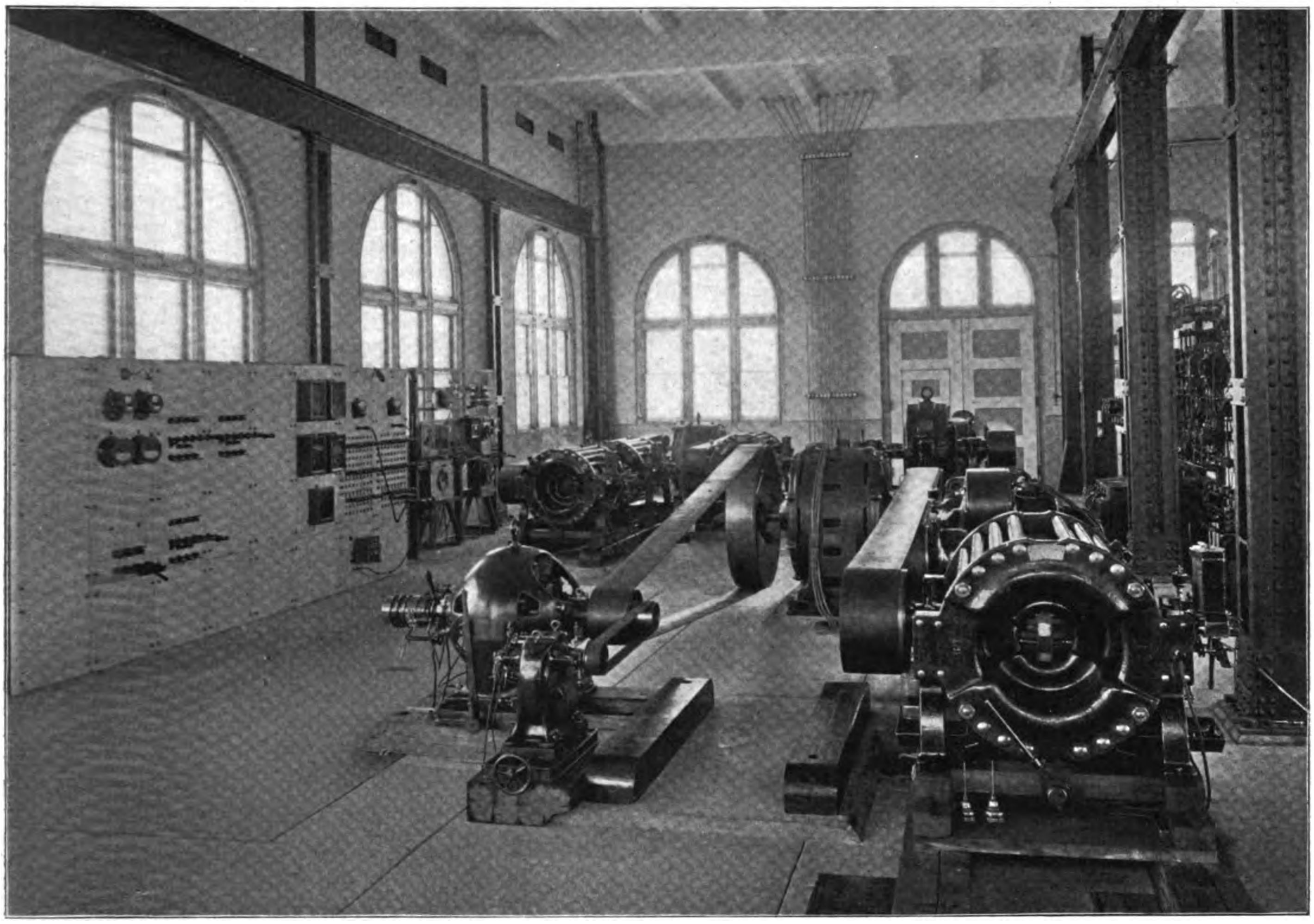


FIG. 10.—A VIEW OF THE CENTRAL STATION BAY, SHOWING INDUCTION MOTORS BELTED TO ARC DYNAMOS AND ALTERNATORS.

The circuit-breakers on the direct-current ends of the rotaries are fitted with auxiliary tripping devices intended to open them if the breakers open on the alternating-current end. In case the a. c. power is cut off, the rotaries continue to run as d. c. motors, taking current from the other stations. This current comes through the series field coils in the reverse direction from normal, weakening the fields, speeding up the machines, causing more current to flow in to keep them running, and finally causing them to run away.

The other bay of the lighting station is at present occupied by three 100-h. p. Westinghouse type C induction motors belted to arc and 125-cycle 1100-volt single-phase alternators. The alternating system is, however, to be changed over to 2200-volt 60-cycle two-phase and carried at night by two 200-kw. direct-coupled motor-generator sets, the motors to be of the induction type. The motors will have eight poles and the generators twenty, giving a ratio of frequency of 8 to 20, or 25 cycles to 62½ cycles when there is no slip. The slip of the motor under load will, however, bring the frequency down to about 60 cycles on the generator end. These two-phase 60-cycle generators will take care of the small motor load, so that it will be necessary to run the 4400-volt 25-cycle circuits only to the larger consumers having motors over five h. p. The present capacity of the lighting system is 275 arc lamps and 2000 incandescents. A 60-kw. belted set will be installed for the day load. A pair of 125-light Brush arc machines will also be installed at some later date, when the load demands them, direct coupled to one motor for carrying the arc load.

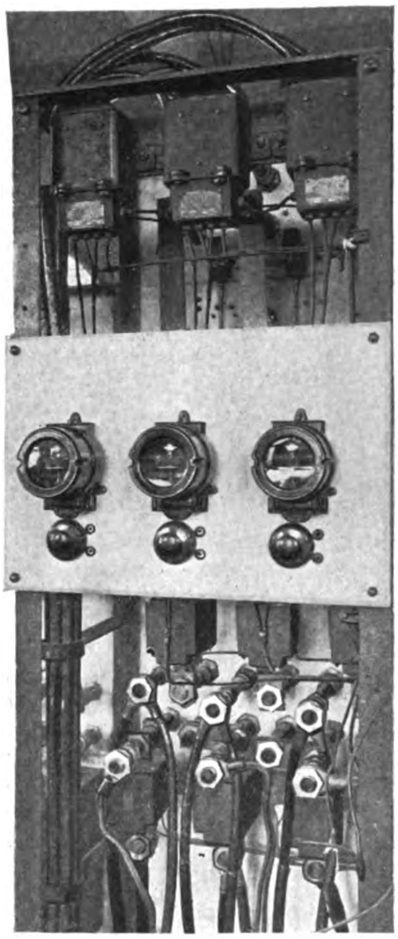


FIG. 11.—THE SINGLE-PHASE RELAYS OF THE REVERSE CURRENT CIRCUIT - BREAKERS WITHIN THE DELTAS OF THE 4400-VOLT AND 360-VOLT SECONDARIES OF THE STEP-DOWN TRANSFORMERS

The credit for the original work involved in the design of this novel station belongs to Mr. L. B. Stillwell, Electrical Director of the Niagara Falls Power Company and associated interests, and to the engineering staff of the Westinghouse Electric and Manufacturing Company. The officers of the Tonawanda Power Company, to whom thanks are due for the information given above, are Mr. A. S. Allen, Superintendent, and Mr. W. A. Gibboney, Electrician. An explanation of many of the unusual alternating-current devices was obtained from Mr. L. E. Imlay, resident engineer of the Westinghouse Company at Niagara Falls, in whose charge was placed the erection of the apparatus in this station.

◆

THE USE OF HOT-WIRE SHUNT INSTRUMENTS AS ALTERNATING AMMETERS.

BY E. A. WAGNER.

The increasing practice of using alternating currents at a high voltage for the transmission of power and transforming at either or both ends of the line so as to obtain a lower voltage and large currents, has created a demand for a method of measuring these heavy currents which can be relied upon as being fairly accurate when installed after the instruments have been calibrated in the laboratory.

In direct-current practice the use of a low-reading voltmeter connected across a low-resistance shunt has proven very satisfactory. Stray fields do not affect the drop in the shunt and their effect upon the instrument can be overcome by shielding it, or by using a hot-wire instrument, so that the readings obtained are quite reliable. The sum of the currents passing through the shunt and the meter is equal to the current in the main line.

If an alternating current is passed through the line, the current will divide through the shunt and meter in inverse ratio to their impedances, not in inverse ratio to their resistances. At any instant, therefore, the vector sum of the currents flowing through the meter and the shunt is equal to the current in the line.

If the relation between the reactance and the resistance is the same in the meter as in the shunt, then it is apparent that the current will also divide as in the direct current case—in inverse ratio to their respective resistances, and a calibration by direct current is reliable. It is common practice, however, to use a hot-wire instrument with the shunt. This instrument is placed anywhere from a few feet to sometimes 100 feet away from the shunt, and great care is taken to eliminate self-induction by twisting the leads; in the instrument itself the self-induction is negligible.

The reactance of the shunt, however, will vary within wide limits, depending upon the frequency, current and the relative position of other cables carrying current.

If the self-induction of the shunt is such that the reactance voltage is 50 per cent of the resistance drop and the self-induction of the meter is negligible, the reading of the meter will be in error by more than 10 per cent from the calibration with direct current. The indication of the meter on alternating current will be high, i. e., it will give a reading indicating a greater line current than actually exists.

It often happens that the reactance of the instrument bears a greater ratio to its resistance than does that of the shunt, even when the leads from the shunt to the instrument are carefully twisted to reduce self-induction. In this case the reading of the instrument will be low, indicating a lesser current in the line than that actually present.

From the above it is evident that the measurements of alternating currents by means of a shunt is not to be depended upon where the instrument has been calibrated by a direct current. If the calibration is made with an alternating current then the indications will be much more accurate.

A very convenient method of calibrating (indicated in the accompanying diagram) is to have a small current transformer, L, arranged to slip over the cable in series with the shunt, S, and so wound that a 15 or 25-ampere alternating-current ammeter, B, can be conveniently used. If the ammeter, B, is properly shielded, the calibration will be very reliable.

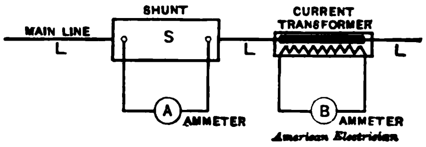


DIAGRAM OF CALIBRATION ARRANGEMENT.

This transformer and meter can be easily calibrated in a laboratory to find the percentage error of the transformer, which should not be more than 2 per cent. at full load. The currents in the transformer will not be affected by the relative position of cables carrying either alternating or direct currents or by the presence of iron.

◆

A SIMPLE INSTRUMENT FOR TESTING CONDENSERS.

At the meeting of the American Institute of Electrical Engineers held on Feb. 28, Prof. M. I. Pupin read a short paper describing an instrument for measuring the capacity of condensers. The principle upon which the instrument is based is illustrated diagrammatically by Fig. 1. If a non-inductive resistance be connected as shown to a source of e.m.f., a condenser, C, of known capacity, a condenser, K, of unknown capacity, and a differentially-wound telephone receiver, I; when the slider, s, is so adjusted that making and breaking the telephone circuit causes no click of the diaphragm, the capacity of K will bear the same relation to that of C that the resistance, SA, does to SB.

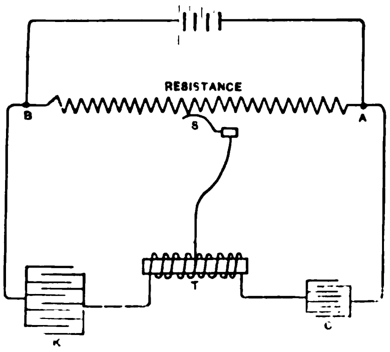


FIG. 1.--FUNDAMENTAL DIAGRAM.

Fig. 2 shows the arrangement of an actual apparatus. Here A is a cell which feeds into the primary, B, of a small induction coil provided with an interrupter such as is used in electrotherapy. The secondary, C, is connected to a row of resistance coils, E and L. These resistances are arranged in convenient steps as indicated. The resistance coils, L, have in addition several equal lengths of manganin wire, F, stretched over a graduated scale. The resistance of the coils as well as of the manganin wire is carefully calibrated once for all. The condenser, H, is a carefully constructed mica condenser of known capacity. G is the condenser the capacity of which is to be determined. I is the differentially-wound telephone. The approximate adjustment is accomplished by the plugs which control the resistances E and L, and the final adjustment is made by the manganin wire by a sliding contact, F, which varies the length of the manganin wire to be introduced, and therefore varies the drop which acts on one of the condensers. With ordinary frequencies capacities up to several microfarads can be determined with an accuracy of a small fraction of 1 per cent. easily and rapidly.

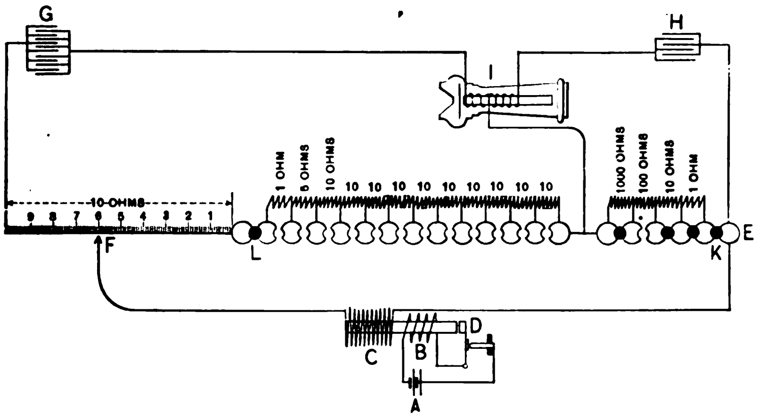


FIG. 2.—DIAGRAM OF ACTUAL APPARATUS FOR TESTING CONDENSERS.

It is self-evident, of course, that in place of the differentially-wound telephone, I, we can use an ordinary telephone and place it in the bridge which connects a point between G and H to a point between the resistance coils E and L. The conditions of balance are the same as in the method employing the differentially-wound telephone. In many practical cases this second method is preferable.

DIFFERENTIAL TESTING WITH SINGLE-COIL INSTRUMENTS.

BY GEORGE T. HANCHETT.

There are many cases which arise in electrical testing where it is desirable to measure two different values of voltage or current and subsequently to subtract them. This usually requires two readings made in quick succession or two simultaneous readings made with two separate instruments, or better still, a differential instrument having two coils which are opposed to each other in magnetic effect. A differential ammeter or voltmeter is an expensive instrument, and it is seldom that sufficient testing arises to justify its purchase. As a great convenience, however, it is beyond question. By a little ingenuity in making connections it is possible to arrange an ordinary voltmeter or ammeter to measure the difference between two pressures or two currents.

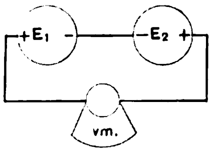


FIG. 1.

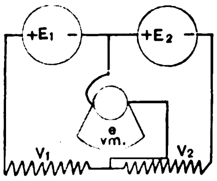


FIG. 2.

The simplest case is that of two independent electromotive forces which can be connected in any way desired. They may then be advantageously connected in opposition, as shown in Fig. 1, when a voltmeter placed between the two free terminals will measure the difference in pressure between the two e.m.fs. It sometimes is the case, however, that two machines are connected in series, such as, for instance, two railway motors or two dynamos on the three-wire system. In such a case the expedient shown in Fig. 2 is advisable. Two resistances which are exactly equal to each other are connected in series; to the common junction of these two resistances is connected a voltmeter and to the three free terminals are connected the electromotive forces to be measured.

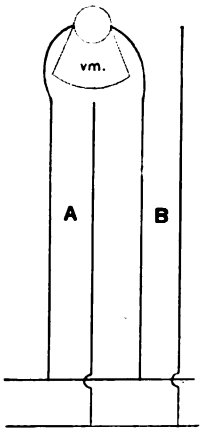


FIG. 3.

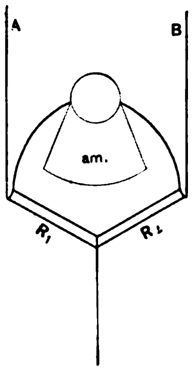


FIG. 4.

The fall of potential in the resistances is denoted by V_1 and V_2. The electromotive forces are respectively denoted as E_1 and E_2, while the instrument reading is represented by e. On this basis, and taking due regard for algebraic signs, we have the following equations:

$$E_1 - V_1 = e.$$

Due to the equality of the resistances, we have,

$$V_1 = \frac{E_1 + E_2}{2}.$$

Substituting,

$$E_1 - \frac{E_1 + E_2}{2} = e,$$

and simplifying we obtain

$$\frac{E_1 - E_2}{2} = e.$$

That is to say, the difference in the two electromotive forces is equal to double the reading of the instrument, e. In order to insure accuracy, the instrument, e, must take a very small current as compared with the current flowing through the two resistances.

For measuring electromotive forces on the three-wire system the resistances may be lamps, the resistances of which have been found to be equal at full candle-power, while the voltmeter should have a resistance of from twelve to fifteen thousand ohms. The equality of the resistances should be tested by taking the drop around each with a voltmeter. This arrangement is convenient for inspecting the performance of any current-generating or absorbing devices connected in series. It may be used with great facility in comparing the voltage of two storage cells in

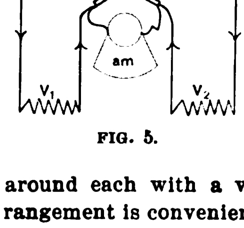


FIG. 5.

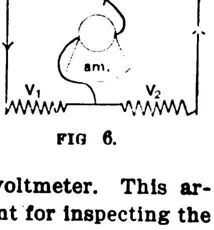


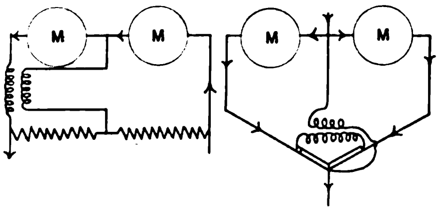
FIG 6.

series, one of which is sulphated or for other reasons exhibits a different electrical condition from that of its mates.

The simplicity of the first device has probably made it familiar to most of the readers of this article, but the writer has known a number of cases where advantage has not been taken of it. For instance, suppose it is desired to compare the drop in two feeder lines, A and B, as shown in Fig. 3. It is not necessary to measure the drops separately. The observed potential difference between the extremities of the lines of like polarity gives the desired difference in drop.

It is sometimes desired to measure the difference between two currents; a common case is shown in Fig. 4, where a current divides, part going on one branch, A, and part on another, B. It is desired to measure the difference in current between these two branches with a single reading. An ammeter of the shunt type is selected and two shunts are provided and connected in the branches as shown. The indication of a voltmeter connected in place of the ammeter shown would be obviously proportional to $C_1 R_1 - C_2 R_2$, and if the instrument is calibrated to read amperes directly on one of the shunts, it will read the difference in amperes on the pair, provided, of course, that the shunts are of the same resistance. This arrangement is adapted to measure the difference between currents in any two circuits in parallel, such as two railway motors on the parallel notches, two lighting circuits or two feeders. If the circuits are independent, as shown in Fig. 5, the measurement can be effected without connecting them in parallel by means of providing a common return as shown in that diagram. The principle of the method of measurement is identical, the circuits having common connections only on one side of the load and working as independently as they did before.

If the devices are connected as shown in Fig. 6 the instrument may be placed in the common circuit, and two shunts are unnecessary. In this case the principle is the same as that by which an ammeter on the neutral of the three-wire system measures the difference in the current load of the two sides.



FIGS. 7 AND 8.

By a combination of these principles a wattmeter connection can be made which will enable a single instrument to record the difference in power given to two electrical devices operating from the same source. The case shown by Fig. 7 is that of two motors, M, M, in series. The series coil of the wattmeter is of course in series with the main circuit, but the potential coil is connected between the motors and an equalizing resistance, according to the method of Fig 2. The wattmeter then indicates one-half of the difference in power between the two motors. If the motors are in parallel the arrangement is reversed, as shown by Fig. 8. The potential coil is connected across the mains and measures that function of the power which is common to both machines. The current coil is connected to the machine by the differential ammeter principle of Fig. 4, and the wattmeter reading is the difference of the powers given to the two machines.

A Single-Cylinder Compound Engine.

Most engineers are aware, of course, that engines have been built in which the steam is exhausted from one side of the piston to the opposite side of the same piston, continued expansion being thus obtained without the use of two cylinders. In such engines the area of piston first exposed to the action of the steam is usually made less than that of the second side by the use of a plunger, giving the effect of two single-acting cylinders of different sizes. A somewhat similar arrangement is known in England as the Cornish cycle. In this case, however, the piston area acted upon by the steam is the same on both sides.

An interesting engine of this type has recently been brought out in Ipswich, in which a central valve, similar to the Willans valve, is employed. Figs. 1 and 2 give sectional elevations of the engine. The valve casing is located in the center of the piston, which is thus turned into a ring. This construction renders the use of duplex piston rods necessary, as shown in Fig. 2. The upper ends of the cross-head guide terminate in cylinders, and at the back of the cross-head are plungers fitting in these cylinders. The result is to provide an air cushion, which serves to maintain the thrust on the connecting-rod constant, even when the engine is running at light load. Fig. 3 shows side and edge views of the connecting-rod, which is of the duplex type and provided with a transverse wrist-pin near its center. The function of this pin is to transmit motion through a link to a bell-crank lever, the remote arm of which operates the valve.

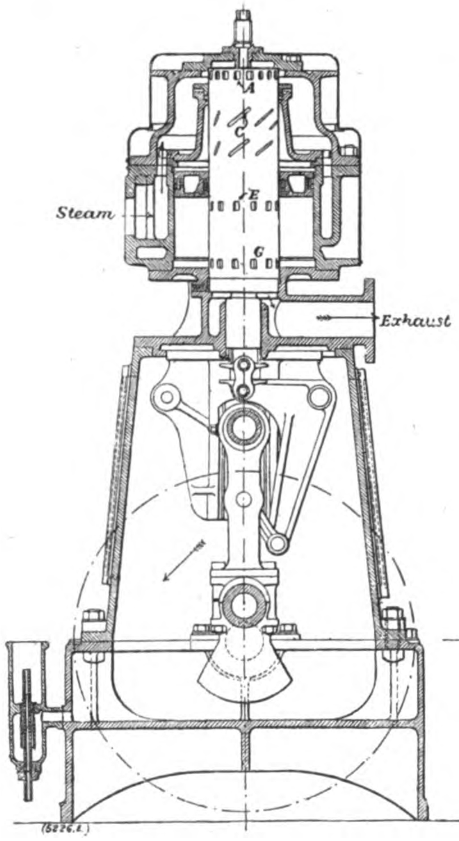


FIG. 4.—TRANSVERSE SECTIONAL ELEVATION.

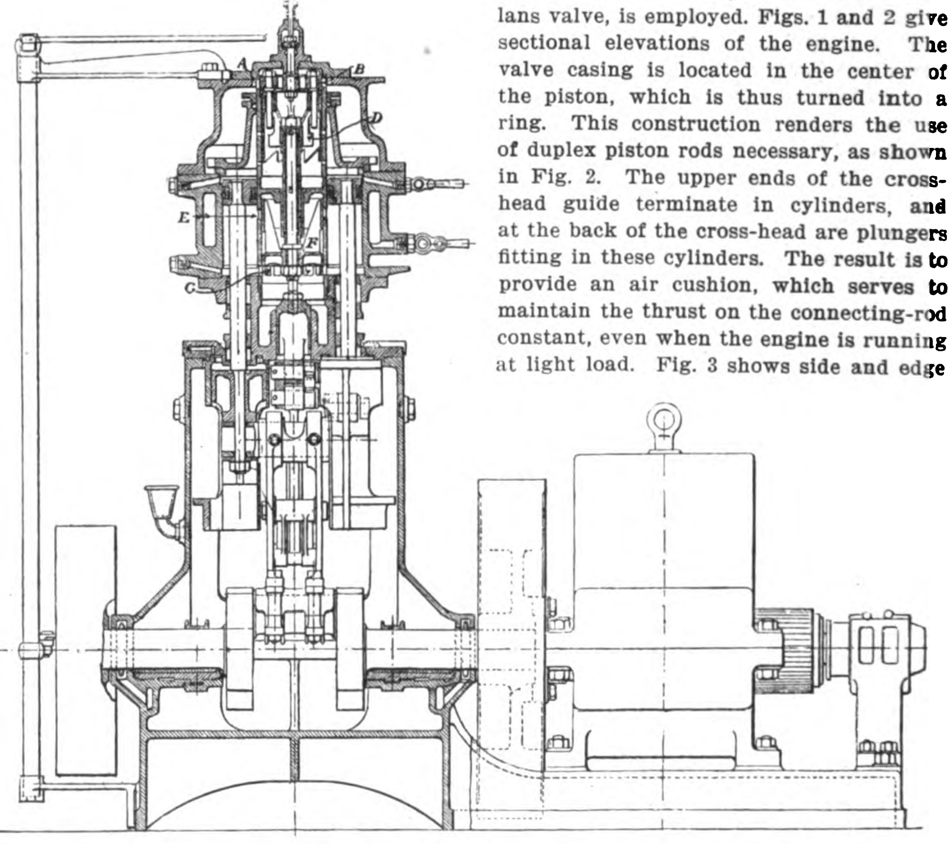


FIG. 2.—LONGITUDINAL CROSS- SECTION.

This construction is more clearly shown in Fig. 1.

There are five sets of ports in the valve casing, three above the central horizontal diaphragm and two below it. The part of the structure above the diaphragm constitutes the high-pressure steam chest and the upper series of ports, marked A, serve to admit steam from the steam chest to the interior of the valve, whence it passes out through the helical ports, C, above the annular piston. At the proper point steam is cut off by the valve covering the ports, C, and expansion begins. As the piston passes down it ultimately uncovers the ports, E, leaving them open to the cylinder, but the lower valve inside of the casing keeps these ports covered until the piston reaches the end of its downward stroke, at which point the valve opens the path between the ports, E, and the ports G, the latter of which are always below the piston. This last-mentioned action obviously allows the steam to pass from above the piston to the clearance below it, establishing equilibrium between the two sides, and the piston is carried up idle by the connecting rod until it covers the ports, E, at which point expansion commences below the piston and compression above it. These actions are continued up to the end of the up-stroke, when the valve uncovers the ports, G, allowing the steam below the piston to exhaust. Live steam is then admitted to the top of the piston again, and the cycle just described is repeated.

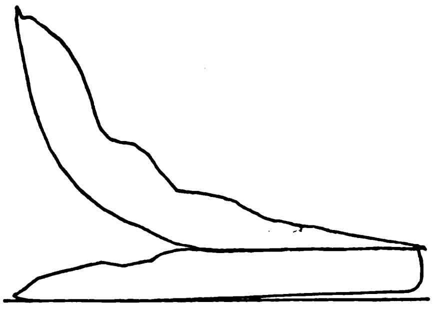


FIG. 2.—DIAGRAM TAKEN NON-CONDENSING.

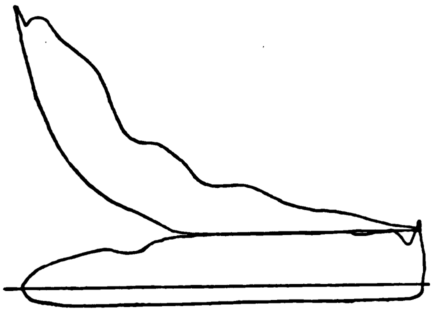
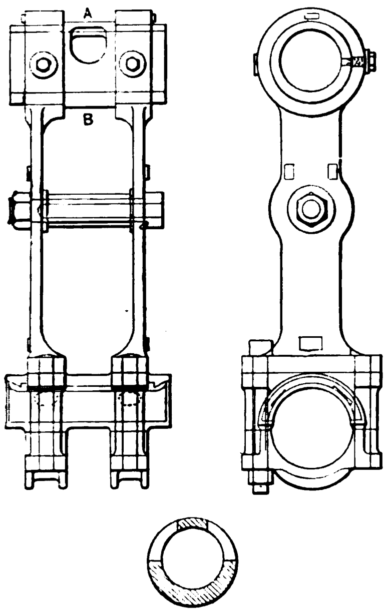


FIG. 3.—DIAGRAM TAKEN CONDENSING.



Section on A.B.

FIG. 3.—CONNECTING ROD.

Indicator cards taken from this engine are shown by Figs. 4 and 5, the upper diagram on each card showing the performance above the piston, and the lower diagram that below it. The valve gear is so arranged that the ports, E, are closed on the upward stroke of the piston at such a point that the connecting rod never exerts a pull on the crank pin, there being constantly maintained a thrust between the piston and the crank pin. During the first part of the return stroke, when the path is open between the two sides of the piston through the ports, E and G, the crank pin is pushing the piston up, and when the piston reaches its point of maximum velocity, where its inertia would tend to cause it to pull the rod out of thrust with the crank pin, the ports, E, are closed, and compression begins above the piston, insuring a continuance of the thrust. The clearance space above the piston is so proportioned as to carry the compression clear up to the initial steam pressure, as the upper diagrams on the two cards plainly show, so that the loss from condensation is considerably reduced.

Another rather unusual and interesting feature of the engine is its governing arrangement. Regulation is effected by varying the cut-off, and this is done by rotating the upper valve on its spindle; the ports, C, which lie in the travel of this valve, being helical, a very small amount of rotation on the part of the valve alters the point of cut-off considerably. The governor construction is shown by Fig. 6. The controlling weight is made in a generally circular form and pivoted at G; the retractile spring opposing the centrifugal action of the weight is secured to a stop at B. Inspection of the illustration will show that the oscillation of the ring-shaped weight about its pivot, G, causes the link, D, to reciprocate, and this transmits its motion to a rock shaft E, provided with a radial arm, F, the end of which coincides with the center of rotation of the engine shaft. The end F, of the rocker arm forms part of a ball-and-socket joint, the other half of which constitutes the extreme end of a rocker arm mounted on a vertical rock shaft, not shown.

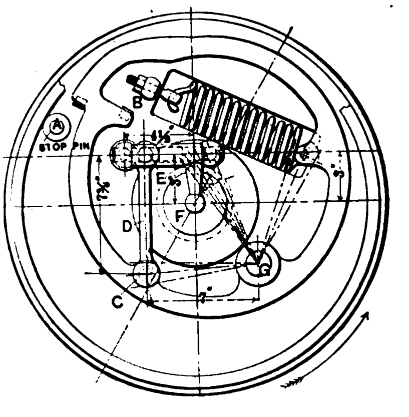


FIG 4.¬THE GOVERNOR.

As the ring-shaped weight is thrown away from the stop pin, A, the ball-and-socket joint at F moves outward, rotating the vertical rock shaft, not shown. This rock shaft at its upper end is provided with means of transmitting its motion to the steam valve. It rests on a ball-bearing step, so that it does not introduce sufficient friction to make the action of the governor sluggish. The weight ring of the governor is so pivoted that its own inertia plays a part in the regulation of the engine in a similar manner to the action of the well-known Rites governor now extensively used in this country.

Tests of an engine direct connected to a 48-kw. dynamo seem to have given good results as to steam economy and speed regulation, as the appended table shows.

Record of Engine Test.

Dynamo rated output, 436 amperes, 110 volts. Engine size, 16 in. x 8 in. Dates of test, January 26 and 29, 1900.

Test Number.	Steam Pressure.	Vacuum.	Speed.	Output.			Diagrams.			Steam per Hour.			Combined Efficiency.
				Amperes.	Volts.	Kilowatts.	Mean Effecti'e Pressure.		Ind. Horse Power.	Total.	Per Indicated Horse Power.	Per Kilowatt.	
							Low Pres.	High Pres.					
I.	160	......	408	440	110	48.4	35.0	33.9	84.2	1613	19.16	33.0	77.2
II.	160	.....	410	330	110	36.3	21.4	28.5	61.3	1230	20.1	33.9	79.4
III.	160		412	220	110	24.2	13.5	21.3	43.0	924	21.5	38.2	75.5
IV.	160	......	412	110	110	12.1	7.9	14.1	27.2	658	24.2	54.4	59.7
VI.	157	26.75	412	520	110.5	57.5	42.0	34.75	94.35	1587	16.82	27.6	81.8
VII.	157	26.75	412	440	110	48.4	32.5	30.18	78.3	1300	16.6	26.9	83.0
VIII.	155	26.75	412	330	110	36.3	24.06	23.31	58.3	1008	17.3	27.7	83.5
IX.	159	25.50	412	220	110	24.2	18.81	15.81	42.6	735	17.25	30.4	76.1

Governor Trial.

Lead......	0	¼	½	¾	Full	Highest speed reached with load thrown off, 420.
Speed...............	414	412	410	408	406	

According to the table the indicator card of Fig. 4 was taken with the engine running condensing, and that shown by Fig. 5 was taken running condensing with a vacuum of 26.75 ins.

From the foregoing description it will be clear that this type of engine is not a compound in the ordinary sense, as only a portion of the volume of steam admitted to the upper side of the piston is carried through a second expansion. On the completion of the down-stroke and during part of the up-stroke, the steam is divided into two parts; about half of it is compressed above the piston on the up-stroke, while the other half expands below the piston and serves to relieve the back pressure of compression. Of course, the work done by the expansion below the piston is useful work, and the excessive compression on the upper side reduces the cylinder condensation very greatly, besides conducing to smooth running.

Generally speaking, the engine is equivalent to a two-cylinder compound the cylinders of which are of the same size, with cranks 180 degrees apart, and in which the exhaust valve of the high-pressure cylinder closes and the steam valve of the low-pressure cylinder cuts off about midway of the stroke, the cut-off of the high-pressure steam valve being varied for the purpose of regulation. The single-cylinder arrangement possesses the obvious advantage of much less area of steam surface, while it has the disadvantage of being practically single acting. This latter drawback is largely compensated by the high rate of speed obtained.

We are indebted to "Engineering" (London) for the details of the tests, indicator diagrams and other information.

THE USE OF THE STORAGE BATTERY IN THE THEATRE.

BY "X. Y. Z."

The greatest advance in the art of stagecraft in recent years has undoubtedly been due to the improved method of lighting by means of the incandescent electric light. The theatrical "gas man" of not so many years back has given place to his brother, the electrician, who, thanks to the incandescent light, is able to produce effects which were not even dreamed of in the days of gas.

The modern playhouse is lighted electrically throughout, and by means of regulating rheostats, technically known as dimmers, these lights may be "turned down" to any desired degree. The stage itself is equipped with electrical footlights, proscenium lights, and border lights, while from floor to gridiron there is a perfect network of receptables for the operation, by means of plug and flexible cord, of bunch lights, spot lights, and low-tension hand-feed arc lights for local illumination, as well as the multiplicity of lights used in certain sets showing interiors.

All the wiring in the house, for ease in operation, is brought to a switchboard, usually located at the left hand of the proscenium arch, where the electrician is able to control any single circuit, or, by means of gang switches, all the lights simultaneously by a single motion of his hand.

From the foregoing it would seem as though absolute perfection had been attained and nothing were left to be desired, but such is not the case by any means.

In the majority of theaters the supply of current is furnished either from the mains of the local lighting company, or by a generating plant installed in the theater itself (a duplicate set being kept in reserve in case of breakdown), the latter system being chiefly in vogue among the larger cities. Although these generating units are of large capacity, it is a common occurrence that in a great spectacular or melodramatic production an amount of current greatly beyond the normal output of the machine is required for a few minutes at a time, resulting in overloading the generator and consequently rendering it liable to sudden and disastrous breakdown, with the accompanying danger of a panic among the audience, a certain amount of time always being required to start the duplicate apparatus in motion. Interruptions of lighting service from this cause have taken place not once, but many times, and will occur as long as the present system is adhered to. Anyone who has ever experienced this sudden transition from brilliant illumination to appalling darkness, in a crowded theater, has probably been given food for reflection for some time to come.

Since the storage battery is such an ideal remedy for trouble of this kind it is a matter of considerable surprise that it has not been used to a greater extent in American theaters. The storage battery of to-day is as much a standard piece of apparatus as the engine or dynamo, and if handled properly never fails to give as satisfactory results. As a matter of fact it has been brought to such a stage of perfection that it is considered an indispensable auxiliary, and is in use by nearly all the great electric street railway systems and central station lighting plants, as well as in thousands of isolated plants in hotels, apartment houses, office buildings, etc., throughout the United States. Notwithstanding this unanimity of engineering opinion in its favor, large permanent batteries, for some undiscovered reason, have been used to a very limited extent in the theater, although a considerable number of portable cells have been used from time to time for special work. On the other hand, in all the large cities of Europe the storage battery is well and favorably known among theatrical electricians, and the electrical equipment of a first-class theater is not considered complete without it.

The advantages of a storage battery in a situation of this kind are many; either as an auxiliary to the generating plant of the theater, or as a reservoir to be drawn on at will, where current is taken from outside sources. Among these advantages may be mentioned economy in first cost. From an engineering point of view there is hardly any other situation where the question of economy is so little considered as in the electrical plant of the average theater. In the first place, although in use but a few hours each day, the generating machinery must be large enough to take care of the maximum demand that may be made upon it, necessitating the use of apparatus which in point of size is greatly in excess of what would ordinarily be required. The outlay for these large-size generators and the accompanying boiler and engine capacity may be cut down about half, and yet the same, or better, results obtained, much more economically by the installation of a single generator sufficiently large to carry the average load, and a storage battery, which is charged when the load falls below the average, and discharges when it rises in excess, thus keeping the engine and generator steadily loaded, and effecting a considerable saving in coal consumption, not to speak of the increased efficiency in operation of the moving machinery.

The demand for current during a performance in the theater is often of a widely fluctuating character, ranging from but little above zero to extremely high peaks, in a very few second of time, severely racking both engines and dynamos every time it occurs, rendering them liable to serious derangement without an instant's warning; while with a battery floating on the system all danger from this source is practically eliminated, the battery responding instantly and automatically to all demands made upon it, up to the limit of its capacity.

In this connection, it may be stated that it seems somewhat singular that so many of our astute theatrical managers, while busily engaged in stopping leaks in other directions, have apparently overlooked the fact that it is an extremely expensive operation to work engines and generators of large capacity only partially loaded. It is no uncommon thing to see a good-sized generating set run merely to furnish the few lights needed on the stage during a rehearsal. To use a homely but expressive simile, this is a good deal like sending a man on a boy's errand. With a battery auxiliary this loss would be immediately stopped. The small amount of current required during rehearsals could then be drawn from the battery whenever necessary, and in fact if the battery were of sufficient size it would carry the entire load during matinees and thus obviate the necessity of starting the engine at all except for the night runs.

As a regulator the storage battery stands without an equal, and it is probably to this fact more than to any other that it owes its present popularity among the engineering profession. When used in connection with a lighting system a degree of regulation is secured which is as near perfect as could be desired. Many theater-goers have no doubt been annoyed by the "jumping" of the lights, which with the perverseness of all inanimate things usually select the most inopportune time to perform this little trick. This jumping is not due to bad engineering or faulty apparatus, in most cases, but simply to the variable load on the generating machinery and consequent fluctuations in voltage. By the use of a storage battery in connection with the theatrical plant, even where electrical elevators (requiring three times the running current, to start) are used in the same building, it is possible to keep this variation within about two per cent. either way of a fixed limit, a difference which does not affect the lights to an appreciable extent.

In addition to these advantages is the adaptability of the storage battery to supply an enormous amount of current for a short time. Should it be necessary the battery may be discharged in parallel with the generator, thus putting at the command of the electrician a supply of current utterly unobtainable by any other means, and by the use of which he can produce spectacular effects heretofore believed impossible.

The last, and the most important feature of a plant of this kind, is the factor of safety, which cannot be underestimated. By connecting the battery across the house mains at all times, it is an absolute impossibility for the lights to "go off," even in case of the permanent breakdown of the dynamo or engine, or the failure of current from any cause, when taken from outside the theater. A storage battery should therefore, if only considered from the standpoint of safety, be as much a necessity to every theater as the asbestos curtain or the automatic-sprinkler system, and would be well worth its cost from the sense of security it would give both to the manager and his patrons, even if it were never called into service for this purpose. In conclusion, it is hardly necessary to say that the day is not far distant when every playhouse of any consequence will consider the storage battery as an absolutely necessary part of its working equipment.

Fan Motors for 1900.

This season's types of fan motors indicate another step in the direction of uniformity of design, the evident tendency toward which promises to result soon in complete standardization. Most of the desk motors are provided with an adjustable joint between the motor and the pedestal, enabling the purchaser to use the machine either as a desk or as a bracket motor. Self-oiling bearings long ago became standard, and this year shows a general adoption of wick oilers, where the lubricant is not grease.

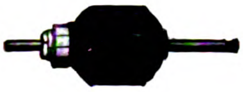


FIG. 1.—G. E. DIRECT-CURRENT ARMATURE.

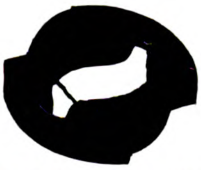


FIG. 2.—G. E. DIRECT-CURRENT FIELD MAGNET AND COILS.

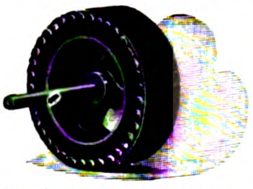


FIG. 3.—G. E. SQUIRREL-CAGE ARMATURE.

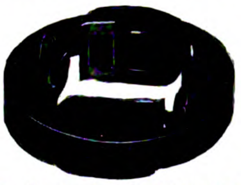


FIG. 4.—G. E. ALTERNATING-CURRENT FIELD.

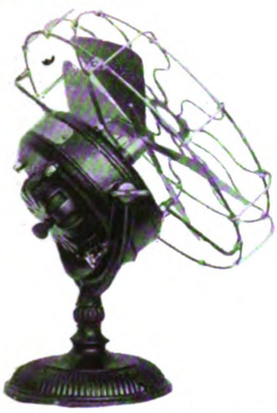


FIG. 6.—G E. ALTERNATING-CURRENT DESK FAN MOTOR; REGULATING COIL IN THE BACK OF THE CASE

Similar approach to uniformity is also noticeable in the magnetic and electrical design. Enclosed field structures, slot-wound drum armatures and carbon pencil brushes are the rule in continuous-current motors, while squirrel-cage armatures and bifurcated field-magnet poles carrying exciting and shading coils are employed in every alternating-current motor save one. In ceiling fans there is not so much uniformity in magnetic and electrical features, but the designs show evidence of a strengthening tendency toward standardization.

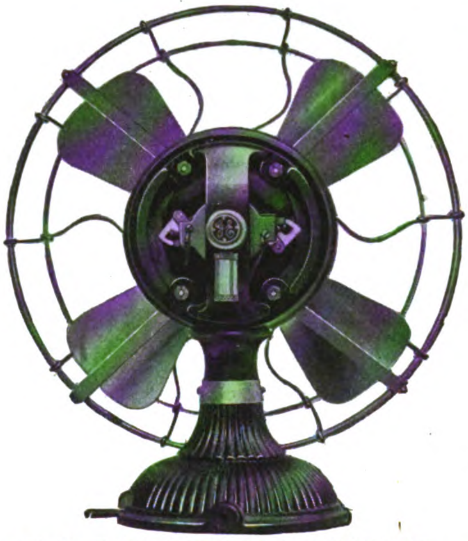


FIG. 5.—REAR VIEW OF G. E. DIRECT-CURRENT MOTOR, SHOWING BRUSH-HOLDERS.

The General Electric desk and bracket fan motors for this year show several interesting changes in details. One of these is the twisting of the slots in the armature core, as shown in Fig. 1; this construction has been adopted in order to eliminate the humming due to the abrupt entrance and exit of the armature teeth into and from the magnetic field. The field-magnet core is laminated and may be removed without dismounting the coils; the core and coils are shown by Fig. 2. The rear view of the motor given by Fig. 5 shows the brush fingers and their relation to the brushes. The latter are rectangular, and the fingers which press them upon the commutator are actuated by coil springs in tension. Speed regulation is obtained by means of a rheostat and switch located in the base of the pedestal. Two styles of mounting are used, the rigid form shown in Fig. 5 and the swiveling trunnion shown in Figs. 6 and 7.

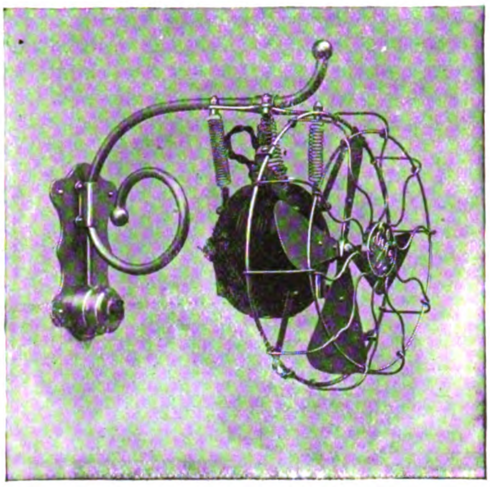


FIG. 8.—G. E. SUSPENSION FOR SMALL FAN MOTORS.

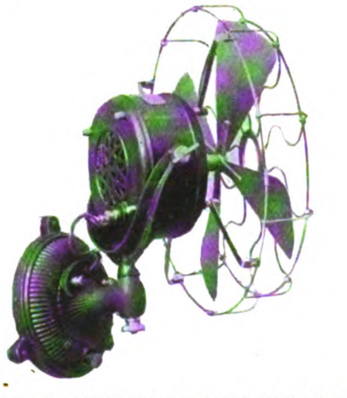


FIG. 7.—G. E ALTERNATING BRACKET MOTOR; REGULATING COIL IN WALL BRACKET.

The motors shown in the last-mentioned illustrations are for single-phase alternating-current circuits. The necessary starting torque is obtained by short-circuited "shading" coils encircling only a part of the magnet poles, as shown in Fig. 4; the "shading" coils are merely rectangular closed loops of copper. The armature or rotor is of the squirrel-cage type, the ends of the bars being riveted to a discoidal ring at each end of the core, as shown in Fig. 3. Speed regulation is effected by means of a reactive or choking coil and a switch which cuts out this coil in sections. The reactive coil of the desk motor is placed in the back of the motor casing, a ventilated extension being provided to accommodate it. The wall-bracket motor is flat at the back, the regulating coil being located in the bracket base. The running speeds are 1150 and 1550 r.p.h. A new mounting for bracket motors is shown by Fig. 8. Spring suspension is employed with a view to preventing the humming due to the transmission of vibrations from the motor to the wall. The application of this feature is particularly advantageous when a motor is to be mounted on a thin partition, such as the wall of a telephone booth.

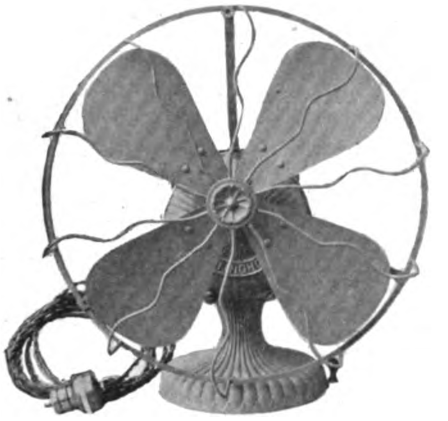


FIG. 9.—WESTINGHOUSE DIRECT-CURRENT FAN MOTOR.

The Westinghouse fan motors for 1900, both for continuous and for alternating current, are completely enclosed by dust-proof housings. The continuous-current fan motor and parts are illustrated by Figs. 9 to 11, inclusive. The motor is intended for 110-volt circuits, but may be operated on circuits of any e.m.f. between 100 and 125 volts. The current taken by the motor is approximately 0.5 ampere at full speed, 0.33 ampere at medium speed, and 0.2 ampere at low speed. The field-magnet core is laminated, as shown by Fig. 10, and carries two coils, which are individually insulated. The object in dividing the field winding into two parts is to obtain variations of speed without the use of a dead resistance. The speeds are approximately 1500, 1000 and 500 revolutions a minute; when running at full speed the two field coils are in multiple; for medium speed one coil is cut out of circuit, and for slow speed the two coils are in series. The armature is drum wound, as indicated by Fig. 10; the slots are closed on top by strips of insulating material which serve to secure the coils in place and render the use of binding wires unnecessary.

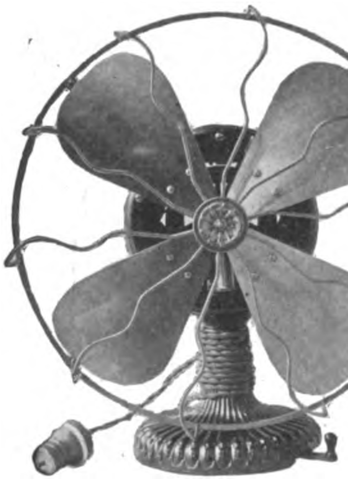


FIG. 13.—WESTINGHOUSE ALTERNATING-CURRENT FAN MOTOR.

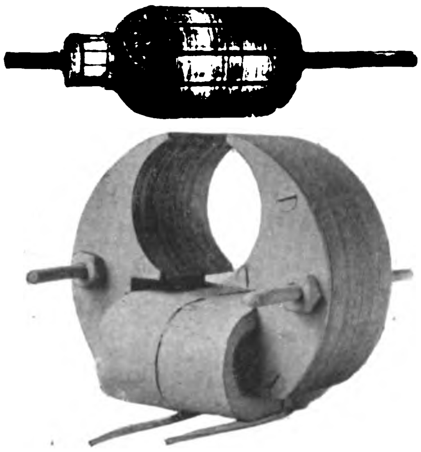


FIG. 10.—WESTINGHOUSE DIRECT-CURRENT ARMATURE AND FIELD MAGNET.

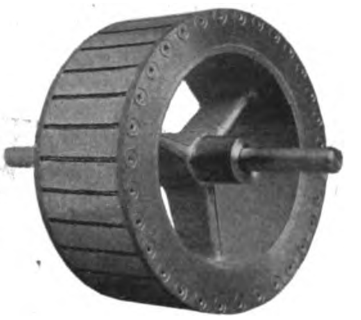


FIG. 12—ROTOR OF WESTINGHOUSE ALTERNATING-CURRENT FAN MOTOR.

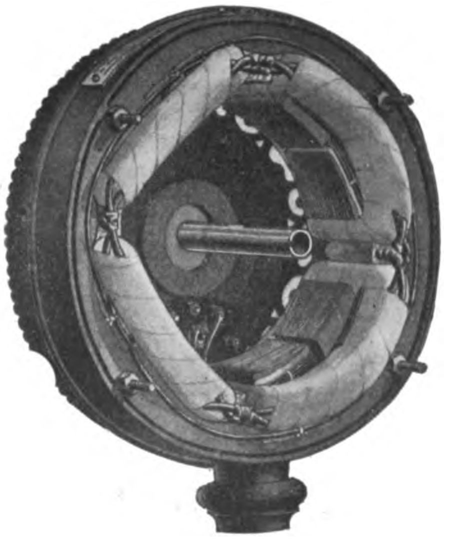


FIG. 14.—INTERIOR OF EMERSON DESK FAN MOTOR.

The Westinghouse alternating-current fan motor shown by Figs. 12 and 13, is of the induction type, and built for use on circuits of 7200 and 16,000 alternations a minute, and for 50 and 100 volts e.m.f.; the motors are not interchangeable for either frequency or voltage. The current consumed by the 50-volt motor is approximately four amperes at full speed and 1.4 amperes at moderate speed. The 100-volt machines take 2¼ amperes at full speed and ¾ ampere at moderate speed. The field ring is built up of thin soft steel plates, with inwardly-projecting teeth, to which the field winding is applied. The armature is of the squirrel-cage type, as shown by Fig. 12, requiring no insulation and no commutator and brushes.

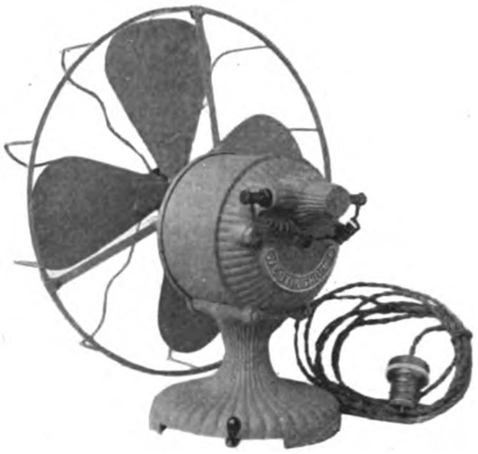


FIG. 11.—WESTINGHOUSE DIRECT-CURRENT FAN, SHOWING BRUSH MOUNTING.

The Emerson desk fan, shown by Figs. 14, 15, 19 and 20, is built only for alternating-current circuits. The field is quadripolar and each pole is practically cut in two by a slot across its center parallel to the shaft, as shown by Fig. 14. In addition to the main field coils, each of which encircles both halves of a split pole, there are "phasing" coils wound one on one-half of each pole. The function of these is to furnish a rotating magnetic field by the action of the current induced in them upon the half-poles on which they are located; this effect consists of throwing the magnetic flux in one-half of a pole out of

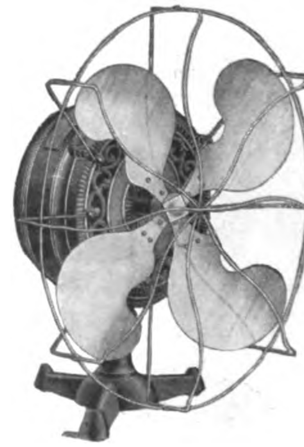


FIG. 15.—EMERSON DESK FAN MOTOR.

phase with that in the other half. This is only necessary at starting; after the motor reaches full speed the phasing coils are cut out and the motor is a plain single-phase induction machine.

The phasing coils are not close-circuited upon themselves, as is usually the case with such windings, but are connected up in parallel with the main field-magnet coils. The effect is to strengthen the half of the magnet pole upon which the phasing coil is wound and to weaken the other half, thus throwing the magnet fluxes in the two halves out of phase with each other and producing a "limping" sort of rotating field, which, though uneconomical for constant operation, serves perfectly for starting the motor up from a standstill.

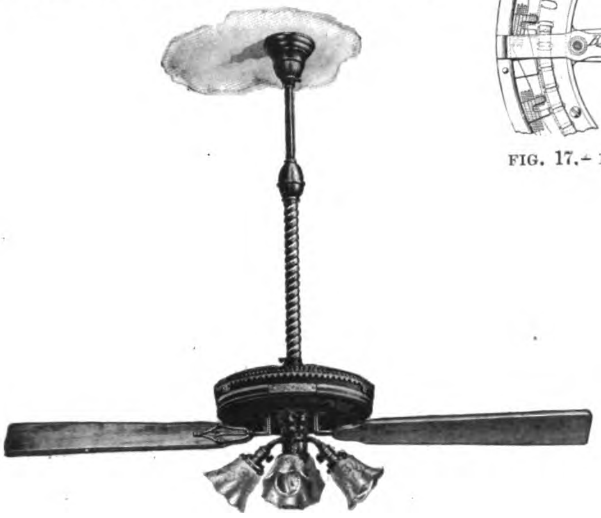


FIG. 16.—EMERSON CEILING-FAN MOTOR.

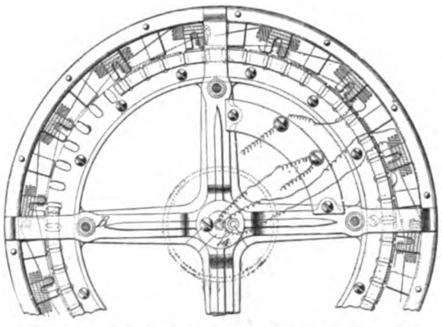


FIG. 17.—DIAGRAM OF EMERSON CEILING MOTOR WINDING.

The armature is shown by Fig. 19. It is of the squirrel-cage type, not the usual arrangement of round rods riveted or soldered to end plates, but a modification of it comprising a slotted core wound with flat copper ribbon or strips, the ends of which are lapped and soldered to complete the closed circuit. The armature bearing is within the core, the part which would ordinarily be stationary being made to revolve about a fixed axle or spindle mounted in the field-magnet frame as shown in Fig. 14. The problem of lubrication is solved as indicated in Fig. 20, where M is the stationary spindle; F, bearing bushings; O, the armature hub or hollow shaft; N, the lubricant chamber; L, oil holes; E, a rawhide washer; D, a felt washer; A, the oil reservoir, and P, the armature core. It is obvious that the oil is fed to the bearing through the hollow spindle, M, passing from its interior to the bearing surfaces through the oil holes, L.

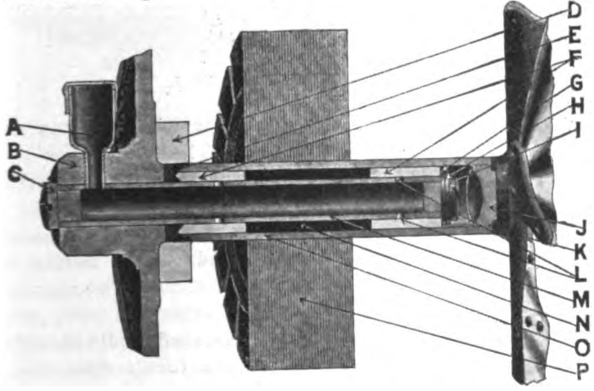


FIG. 20.—BEARING OF EMERSON DESK MOTOR.

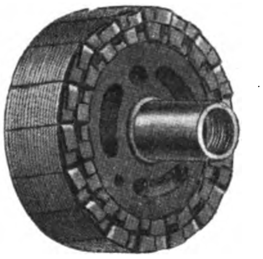


FIG. 19.—ARMATURE OF EMERSON DESK MOTOR.

There are three speeds, the first one being merely for starting, the second one the normal running speed, and the third a slow speed. With the switch on the first point the phasing coils are in circuit and the speed is slightly higher than the regular running speed on the second point when the phasing coils are cut out, but the current consumption with the phasing coils in is considerably higher than when they are cut out so that ordinarily the second switch point is the preferable one for continuous running. The motor may be run, however, with the switch on the first point without any damage, and when a circuit is liable to frequent interruptions it is better to use the first point so that in the event of failure of the circuit while the fan is running it will not be liable to damage when service is restored.

The Emerson ceiling fan, Figs. 16 to 18, embodies the same general principles of design that characterize the desk fan motor. The motor differs in construction, however, from the desk motor in that only the alternate magnet poles are split and wound. This construction is made clear by Fig. 17, which shows a portion of the stator and rotor rings. There are 28 poles, 14 of which are split and provided with main windings and phasing coils. The armature, H, Fig. 18, revolves about a stationary spindle, G, on steel balls, M, and the oil is contained in the reservoir, K. Oil is drawn from the reservoir up to the top of the bearing by means of a helical groove or thread cut in the interior of the revolving sleeve of the bearing, and lubrication is thus maintained along the whole length of the sleeve.

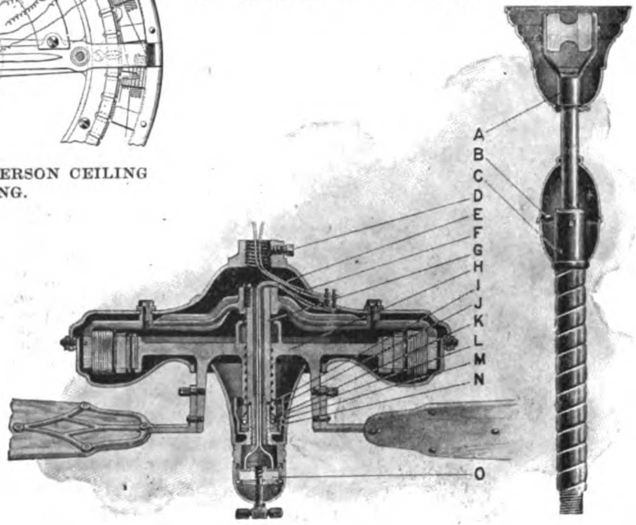


FIG. 18.—SECTIONAL VIEW, EMERSON CEILING-FAN MOTOR.

Fig. 21 illustrates the ease with which a Peerless fan motor of the enclosed type may be dismantled. Simply removing the two bolts shown screwed into the rear-end cap permits the dismounting of the two end caps, as the bolts pass through the field-magnet frame; the armature shaft may be released from the front bearing by removing the fan. The brushes are

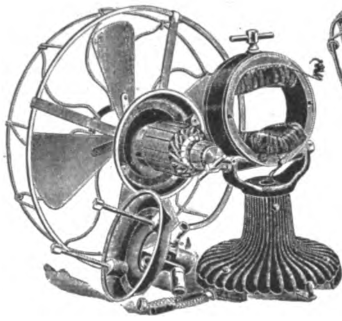


FIG. 21.—PEERLESS ENCLOSED TYPE DESK MOTOR DISMANTLED.

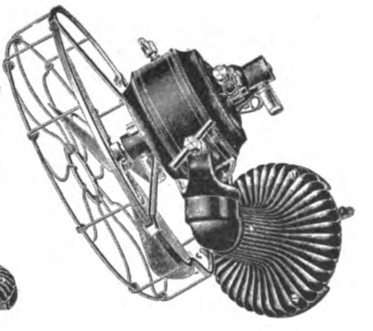


FIG 22.—PEERLESS ENCLOSED TYPE SWIVEL BRACKET FAN MOTOR.

of the carbon pencil type pressed outward from cylindrical holders by means of compression coil springs. The bearings are of the automatic wick-oiling type. These motors are equipped with a regulating rheostat and switch giving three speeds. The speeds and current consumption of the 12-in. fan outfit are 1000, 1350 and 1650 r.p.m. and 0.33, 0.38 and 0.42 ampere respectively, on a 110-volt circuit. The 16-in. fan motor runs at 800, 1100 and 1350 r.p.m., and at 100 volts takes 0.54, 0.58 and 0.65 ampere; the speeds are the same at 220 volts and the current consumption is one-half that for 110 volts e.m.f. These motors are also mounted on a universal swivel joint, allowing adjustment of "aim," this construction being also furnished in connection with a wall bracket, as in Fig. 22.

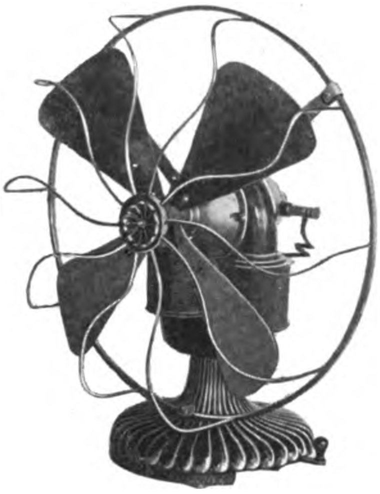


FIG. 23.—PEERLESS OPEN-FIELD DESK MOTOR.

Fig. 23 represents the "open field" Peerless motor, in which the armature is enclosed by caps or hoods at each end and the field-magnet coils are protected by brass shields. The magnet is of the inverted horse-shoe type. This design is mounted on a swivel bracket as well as a pedestal, and runs at three speeds, 1400, 1575 and 1800 r.p.m. for the 12-inch size. The Zero (Western Electric) desk fan motor shown by Fig. 25 is of somewhat similar design. The field magnet is of the same type and the armature is enclosed by means of end caps. At the commutator end small openings in the cap permit inspection of the brushes and commutator. The brushes are of graphite, self-feeding. Speed regulation is effected by means of a rheostat in the base. The bearings are self-aligning and equipped with wick oilers. Fig. 25 shows a 12-inch fan with pedestal mounting, and Fig. 24 shows the bracket mounting.

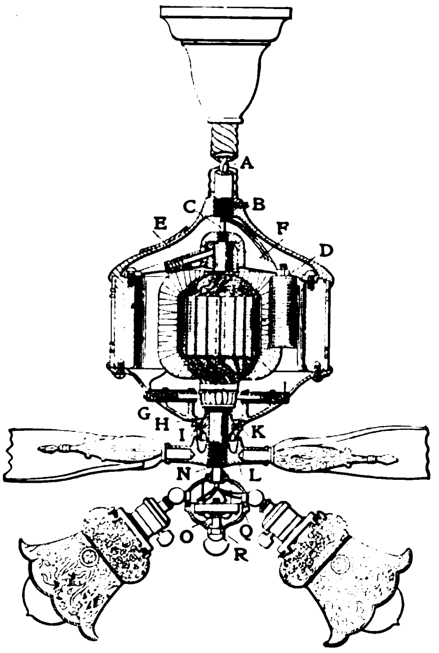


FIG. 26.—WESTERN ELECTRIC DIRECT-CURRENT CEILING FAN.

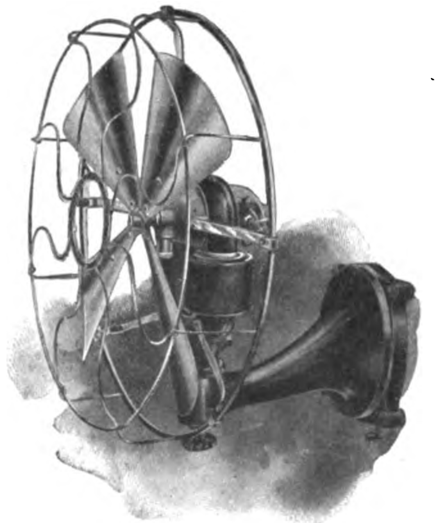


FIG. 24—WESTERN ELECTRIC 16-INCH BRACKET FAN MOTOR.

The Western Electric continuous-current ceiling fan motor is shown in cross-section by Fig. 26. It is a bipolar motor and the plane of the cross-section shown lies at right angles to the vertical plane of the magnet cores. The regulating rheostat is shown at D, and the switch is at O. The suspension stem is shown broken at A, in order to reduce the height of the cut. The armature is mounted so that its horizontal plane lies a trifle below that of the field magnet, the object being to obtain an upward magnetic pull which will assist the reaction of the fan blades to relieve the thrust on the lower bearing due to the weight of the armature. In the Tuerk alternating-current ceiling fan motor a ball thrust bearing is employed at the bottom. Fig. 27 gives a sectional view of this machine, which is of the induction type, and has only one speed. In order to eliminate the use of a multiplicity of magnet poles, a speed-reducing friction gear is interposed between the motor shaft and the fan shaft, as shown in the engraving. There are two leather-faced friction wheels which transmit the motion of the armature shaft to the casing of the motor, the latter being provided with a raised ring around the inside of its upper opening which forms an internal friction gear. The fan blades are mounted on the lower extremity of the casing.

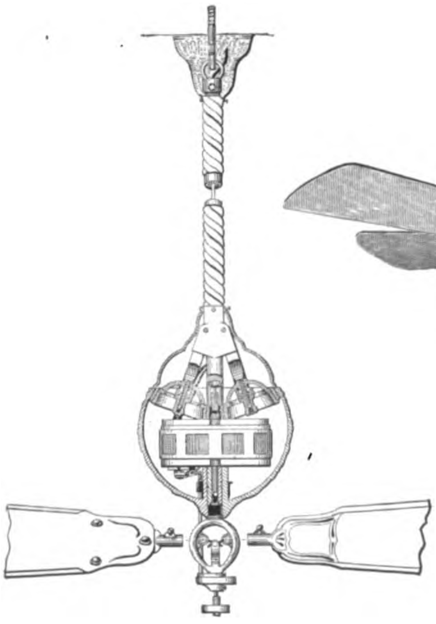


FIG. 27.—TUERK ALTERNATING-CURRENT CEILING FAN.

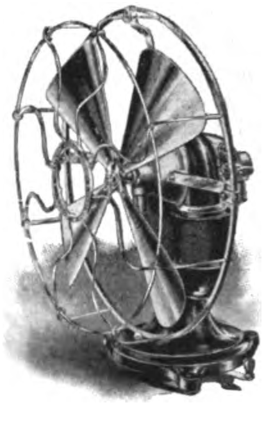


FIG. 25.—WESTERN ELECTRIC DESK MOTOR.

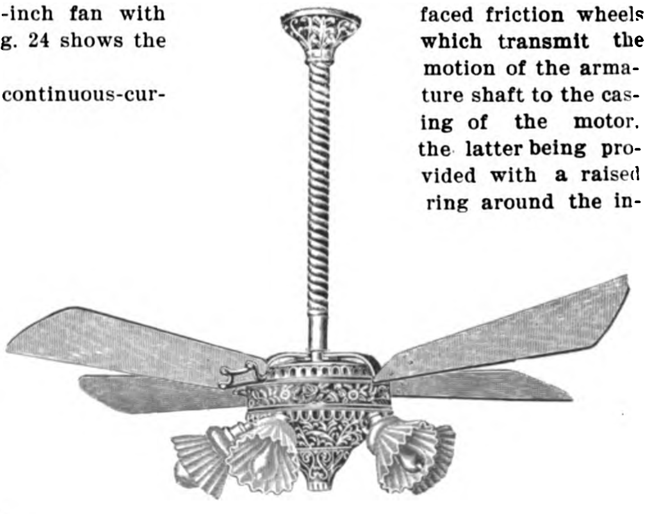


FIG. 28.—BATES CEILING FAN.

A ceiling fan in which the blade suspension is above the body of the motor is the Bates, shown by Fig. 28. The motor is multipolar and the armature coils are form wound and insulated individually before they go on the core. The machine has a single bearing extending from the fan-blade support down to the lower extremity of the motor. It is built with or without the electrolier shown, and for continuous-current circuits of 110, 167, 220, 250 or 500 volts. The manufacturers also build a ceiling fan of the same electrical design, but with the fan-blade suspension below the motor; this is furnished with or without an electrolier, which revolves with the blades. The Tuerk direct-current ceiling fan is similar in appearance. It is wound for 110, 167, 220, 250 and 500 volts, and furnished with a two-speed regulator.

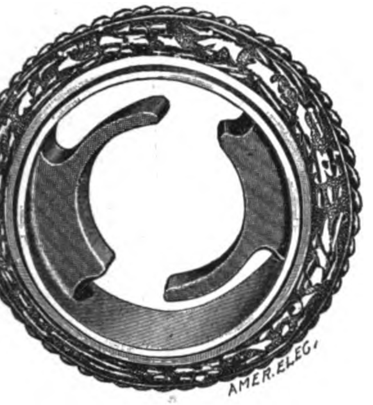


FIG. 29.—FIELD MAGNET STANDARD FAN.

Fig. 30 represents the Standard (Robbins & Myers) ceiling fan, and Fig. 29 shows the peculiar shape of field magnet employed in it. This construction permits the use of a large pole-face area without a joint and without involving the use of non-removable windings. The armature is of the familiar drum type with the winding in slots, and mounted on a turned-steel shaft. The bearings are self-centering, swivel-seated, and provided with metal sleeves running in oil cups which carry a year's supply of oil. The wires leading from the armature to the commutator are firmly bound to an asbestos insulating ring in order to prevent them from breaking by vibration or careless handling, and are soldered into slots milled in the corners of the commutator segment. This location of the wire slots in the segments increases the length of surface available for brush contact. The brushes are of the carbon pencil type, fed from brass shells by compression springs. The insulating hanger is made of leather, the object being to prevent the transmission of vibrations from the fan to the floor of the room above, as well as to avoid the liability to breakage by rough handling in installing the fan. The fans are supplied with the usual speed-regulating switch rheostats, and fans intended to run in series are provided each with a special switch which allows it to be cut out of circuit without stopping any of the other fans in series with it.

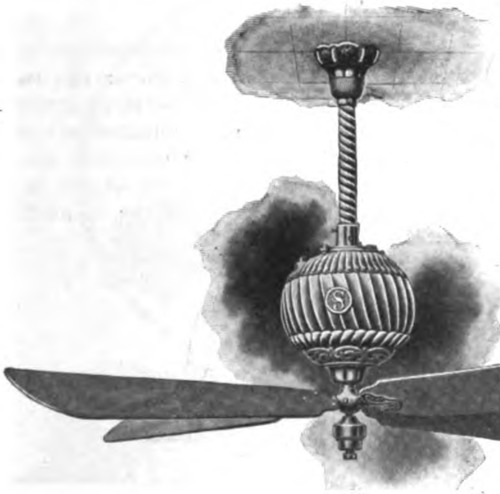


FIG. 30.—STANDARD CEILING FAN.

In the Dayton continuous-current ceiling fan, Fig. 31, an unusually large air-gap area is obtained by running the armature in channels cut in the field-magnet poles, after the style of the Gulcher and Victoria dynamos built in Europe. Three sides of the armature are active, the result being that less wire is required to generate the necessary counter e.m.f. for a given magnetic density in the air gap and a given diameter of armature. The armature core is secured to the cup-shaped inverted canopy by means of screws, X, X. A radial commutator (C) is employed and the brushes (not shown) are mounted on the field-magnet structure. The field-magnet core is of wrought iron and the pole shoes, L, are held on by set screws; the magnet is bipolar.

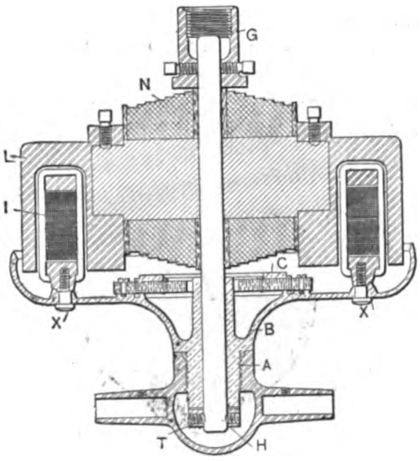


FIG. 31.—DAYTON CEILING FAN MOTOR.

Fig. 32 gives a sectional view of the Dayton "Junior" continuous-current ceiling fan motor, and is practically self-explanatory. The field magnet is bipolar and the engraving shows it with the field coils removed. The main bearing is in the lower casing, and the central part of the fan blade holder, G, is formed into a cup to prevent the escape of oil. A small auxiliary bearing is provided above the commutator, and the shaft carries an oil-retaining cup, I.

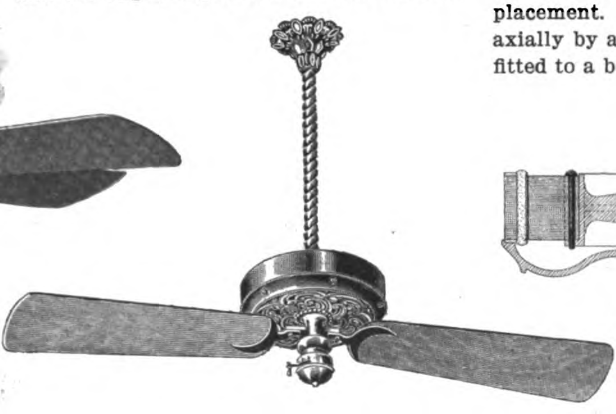


FIG. 33.—DAYTON A. C. CEILING FAN.

The Dayton alternating-current ceiling fan motor, Fig. 33, is an induction machine with an internal field magnet or stator, A. Fig. 34, composed of the usual laminated ring, but with slots around the outside, as the revolving part or rotor, B, surrounds the stator. In this motor the oiling arrangement is similar to that just described, but the thrust is taken by a ball bearing. As in the standard continuous-current motor of the same make, the lower casing revolves with the fan blades. Fig. 38 shows a Dayton alternating-current desk motor in which a single generous bearing is used, oiled by a ring, like the bearings used on most dynamos.

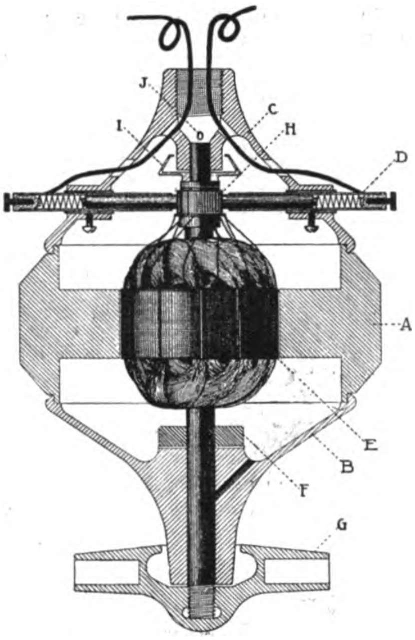


FIG. 32.—DAYTON, JR., CEILING FAN MOTOR.

One of the important features of the well-known Lundell fan motor for continuous-current service is the field-magnet construction. The magnet comprises two forgings exactly alike, one of which is shown by Fig. 35. The two halves are assembled as indicated in Fig. 43, a key or feather-ring being used, as shown in the engraving, to prevent transverse displacement. The halves are held together axially by a circular plate and two screws fitted to a boss on the top of the shell, and a similar arrangement on the bottom. The use of forged iron for the field shell allows the latter to be made thin enough to permit the single-field coil to occupy a plane almost vertical. This arrangement allows the armature to be inserted

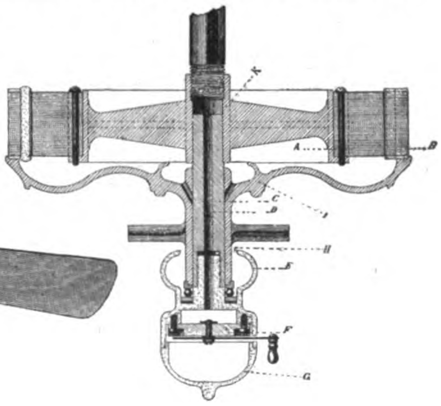


FIG. 34.—SECTION OF DAYTON A. C MOTOR.

and withdrawn without disturbing the field-magnet shell and coil.

As the engraving shows, the openings in the field-magnet shell are closed by caps carrying the journal boxes. The oiling arrangement is shown on the left of Fig. 43, and comprises a wick pressed upward by a coil spring. The brushes are of the familiar plunger type, consisting of carbon pencils housed in metal cylinders and pressed outwardly against the commutator by coil springs. The brush cylinders are mounted in insulating bushings passing through lugs on one of the end caps. Three speeds are available. The current consumption of the 115-volt motor, driving a 12-inch fan at full speed (1800 r.p.m.) is 0.45 ampere.

FIG. 35.—LUNDELL FIELD-MAGNET FORGING.

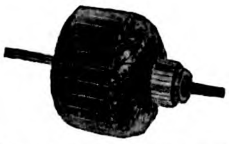


FIG. 36.—ARMATURE OF LUNDELL A. C. MOTOR.

FIG. 37—ARMATURE EMPIRE CEILING FAN MOTOR.

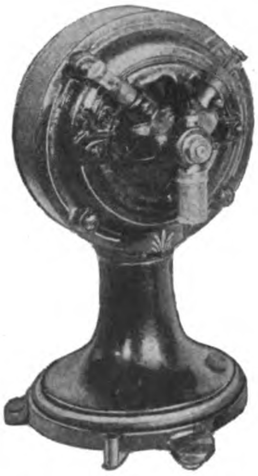


FIG. 39.—LUNDELL A. C. DESK FAN.

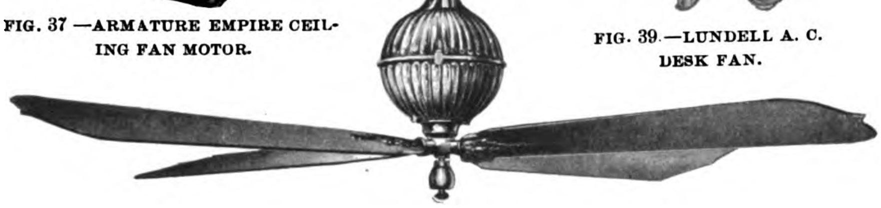


FIG. 40.—COLONIAL CEILING FAN.

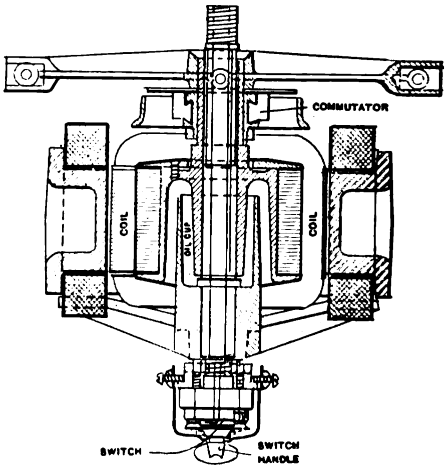


FIG. 41.—SECTION OF EMPIRE CEILING MOTOR.

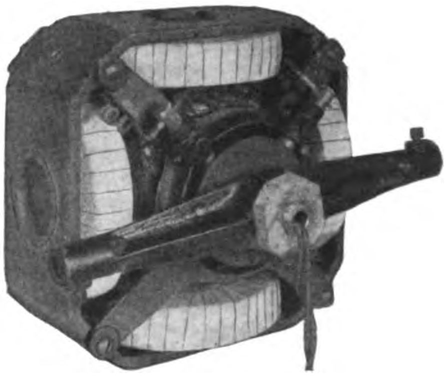
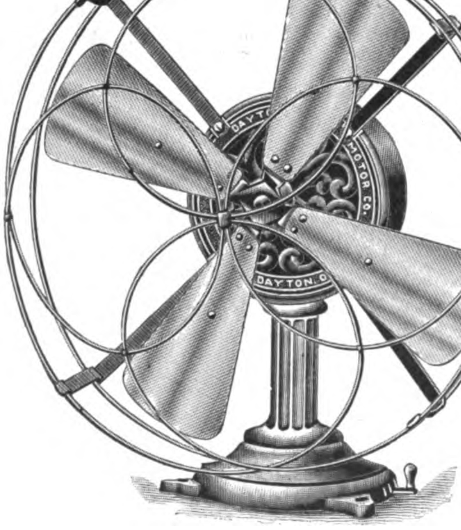


FIG. 42.—EMPIRE CEILING MOTOR.


DAYTON
MOTOR CO.
DAYTON, O.
FIG. 38.—DAYTON A. C. DESK FAN.

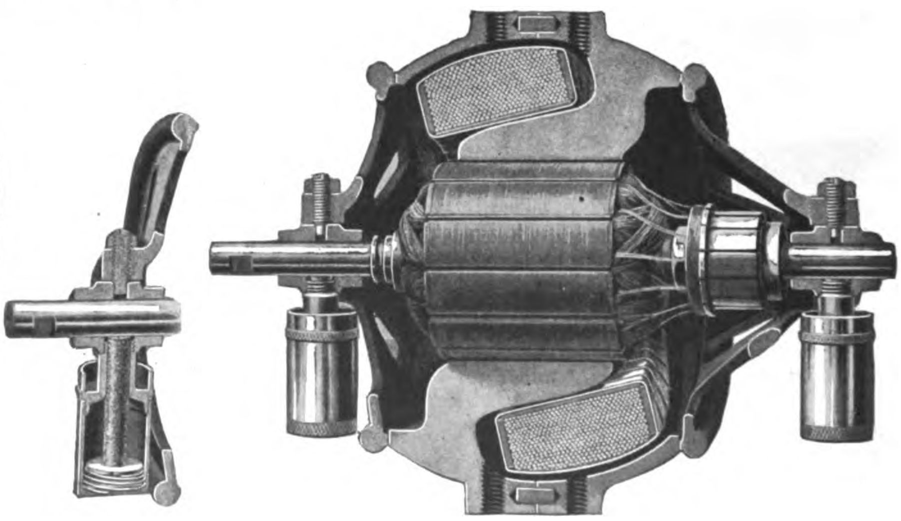


FIG. 43.—DETAILS OF LUNDELL DIRECT-CURRENT DESK FAN MOTOR.

The Lundell alternating-current desk motor is an eight-pole machine with a composite armature winding. A view of the armature is given by Fig. 36. The core carries one set of eight coils, which are close circuited on themselves, and an ordinary drum winding connected up to a radial commutator. The field cores have a plain single winding, one coil on each pole, and this winding is connected in series with the commutator brushes. The motor starts up under the influence of the field and commutated-armature windings as an ordinary series machine. When it approaches synchronism the short-circuited armature windings take hold, making the machine an induction motor, and the armature is carried up near enough to synchronism to enable its inertia to carry it on to an actually synchronous speed. Then the current in the commutated-armature windings becomes rectified and turns the armature into a revolving field excited by a pulsating direct current; the relation between the revolving and stationary members then becomes that of a synchronous motor, the stationary member being energized by alternating current and fulfilling the function of a synchronous-motor armature. The great advantage of this arrangement is that the question of power factor can be eliminated by properly proportioning the excitation of the revolving member of the motor. Fig. 39 shows the complete machine. The Colonial ceiling fan shown by Fig. 40 is an adaptation of the Lundell desk motor just described, the machine being simply turned on the side and equipped with a special thrust bearing. The Empire ceiling motor, built by the same concern and illustrated by Fig. 42, is of the four-pole radial magnet type, with two brushes 90 degrees apart. Fig. 41 shows a cross-section through two of the magnet cores; the two engravings disclose the constructional features very effectually; notable among these is the deep oil cup surrounding the hub of the armature spider. The armature, which is a slot-wound drum, is shown by Fig. 37.

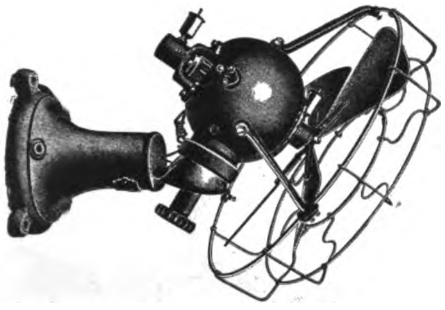


FIG. 44.—HURRICANE BRACKET FAN MOTOR.

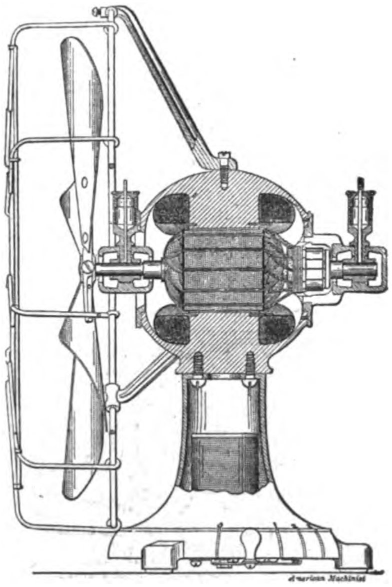


FIG. 45—HURRICANE DESK FAN MOTOR.

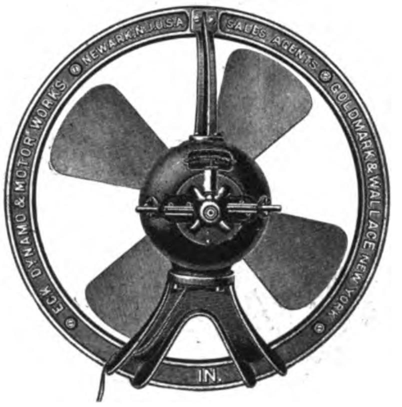


FIG. 46.—HURRICANE VENTILATING FAN MOTOR

The Hurricane (Eck) continuous-current fan motor, the bracket form of which is shown by Fig. 44, embodies several novel features. The exterior of the field magnet is spherical and the magnet is cast in a single piece. It is bipolar and cast with openings at each end, axially considered; the opening at the commutator end is just large enough to admit the field-magnet coils and armature. Fig. 45 is a cross-sectional view of the desk motor, and shows quite clearly the internal arrangement. The brush holders, as shown in Fig. 47, are mounted on a piece of vulcanized fiber, the outline of which is identical in shape and size with the opening in the field-magnet shell on the commutator side. The brushes are of carbon, rectangular in cross-section, and slide in slots in the holders as indicated. A flat spring presses upon one side of each brush and prevents chattering, and the brushes are pushed forward by means of brass plungers carrying projecting pins which engage the rear ends of the carbons; the plungers are forced outwardly by compressed coil springs. Each brush holder is screwed to the shell of the motor, so that the fiber piece connecting the brush holders does not support them but is held by them in position in the shell opening. This disposition is more plainly shown by the rear view of a Hurricane ventilating outfit, shown by Fig. 46.

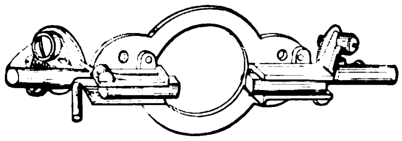


FIG. 47.—BRUSH-HOLDERS, HURRICANE FAN MOTOR.

Lubrication is effected by means of grease cups, as shown by Fig. 45, a point in connection with which is the fact that the cups are not in contact with the motors anywhere except at the bearings.

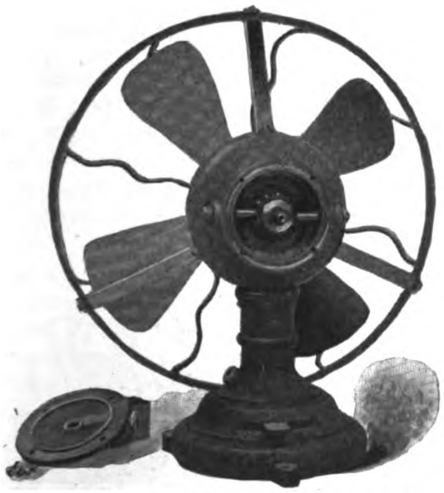


FIG. 48.—HOLTZER-CABOT FAN MOTOR.

A very similar type is the Holtzer-Cabot motor shown by Fig. 48. The shell is generally spherical, and the armature and field-magnet coils are inserted through an opening in the shell, which is afterward closed by the journal cap, shown detached in the illustration. The bearings can be turned to any position, so that the motor can be screwed to a wall or to the ceiling. The bearings are of phosphor bronze and provided with grease cups. The armature is drum-wound in slots, and four running speeds are available by means of a resistance coil and switch in the base.

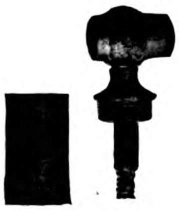


FIG. 50.—PARAGON BEARING.

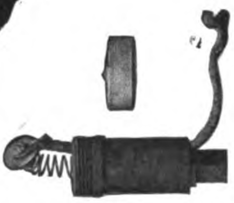


FIG. 51.—PARAGON BRUSH AND HOLDER.

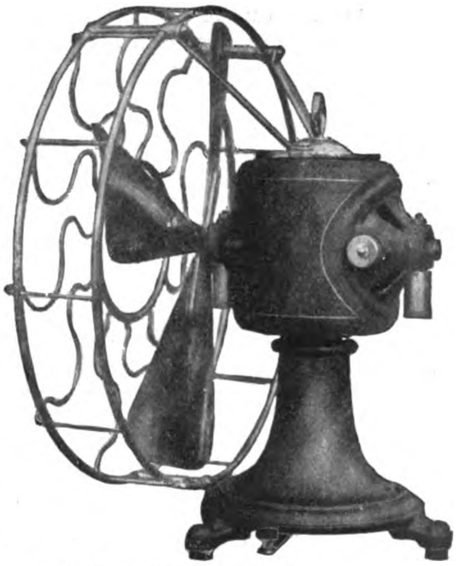


FIG. 49.—PARAGON DESK FAN MOTOR.

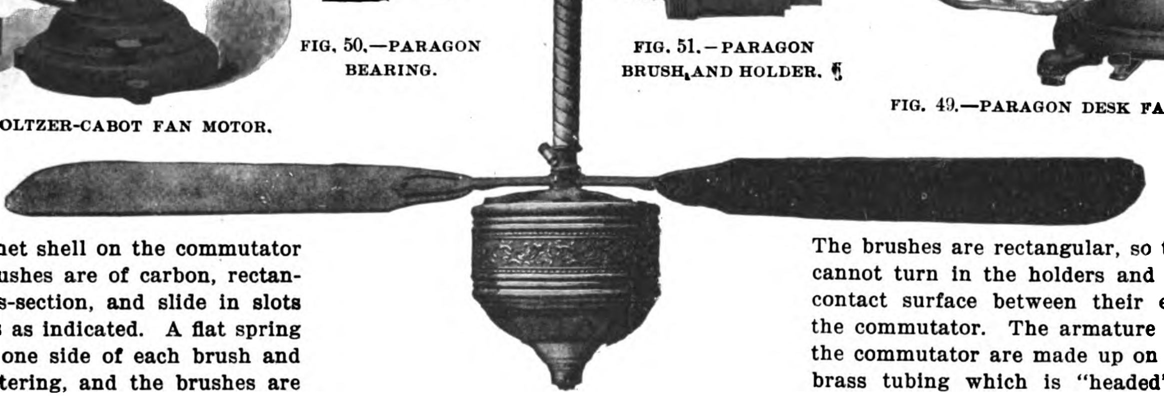


FIG. 52.—PARAGON CEILING FAN MOTOR.

The Paragon desk motor, Fig. 49, retains the general outward appearance and fundamental features of design that have characterized it hitherto. The field magnet is a single casting, the field coils and armature being inserted through the opening in the shell at the commutator side of the motor. Removing the cap or journal bracket at this end, therefore, permits the removal of the armature and field coils. The brushes are rectangular, so that they cannot turn in the holders and vary the contact surface between their ends and the commutator. The armature core and the commutator are made up on seamless brass tubing which is "headed" or expanded at the ends while the structure is under heavy compression. Speed regulation is effected by rheostat, the low speeds being respectively one-half and one-fourth of the maximum. Like many of the fan motors already described, a bracket mounting is employed which includes a ball-and-socket joint. Fig. 52 represents a Paragon ceiling fan and motor in which a ball thrust bearing is employed. The motor design is a modification of the desk machine. Fig. 50 shows the Paragon bearing, and Fig. 51 the brush holder.

The Towle desk fan motor, Fig. 53, has an iron-clad field magnet similar to that of the Paragon machine just described, but differs in details. The Towle ceiling fan, Fig. 55, is new this year. The field magnet is a single casting; it is bipolar, with a circular yoke, and the coils are form-wound and insulated before mounting. The armature is drum-wound and has 28 coils, an unusually large number. The brushes are carbon pencils, and are prevented from turning in the holders by projections on the holders which fit in slots in the brushes. The motor is enclosed by a brass casing, which may be released by simply unscrewing the switch handle at the bottom of the structure, just as in the case of an ordinary snap-switch cover. The motor runs at 180 r.p.m., with the blades adjusted at an angle of 30 degrees.

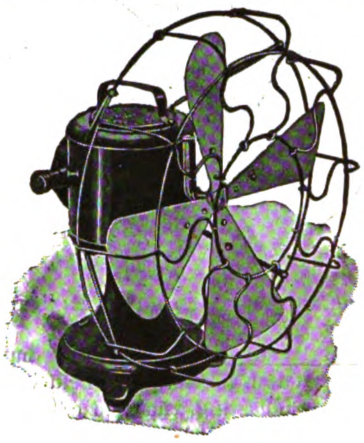


FIG. 53.—TOWLE DESK FAN MOTOR.

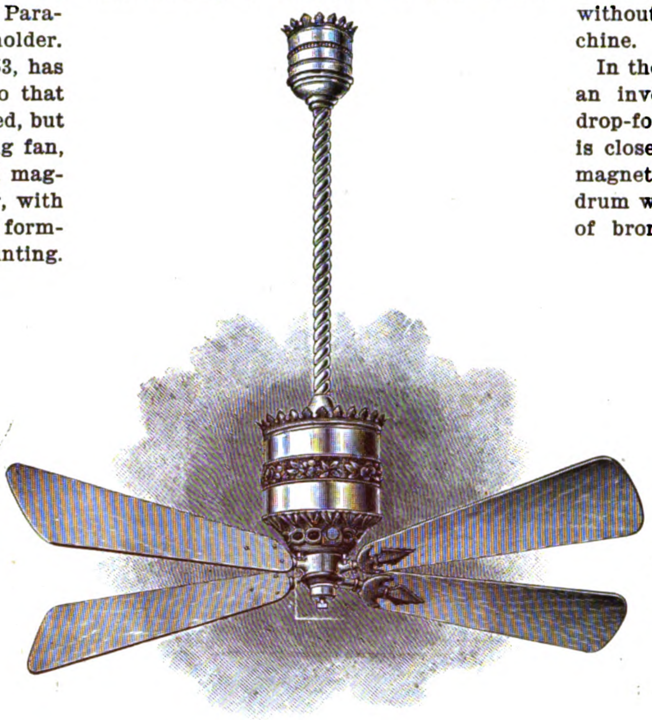


FIG. 54.—DIEHL CEILING FAN MOTOR.

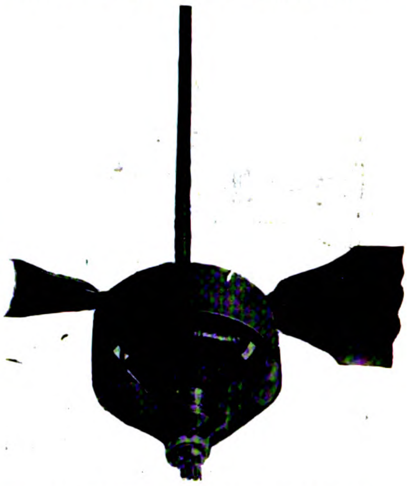


FIG. 55.—TOWLE CEILING FAN MOTOR.

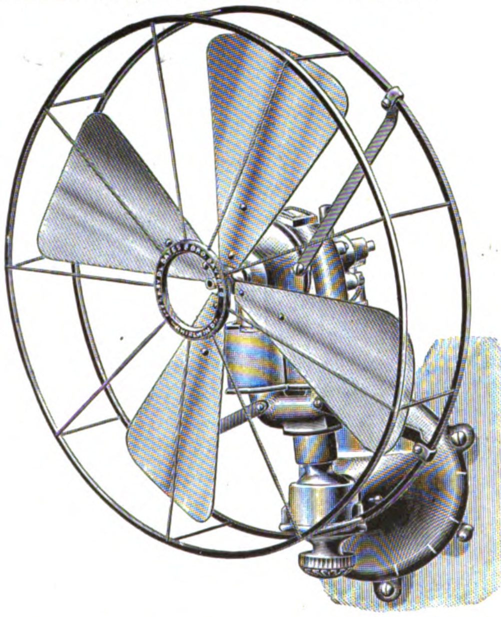


FIG. 56.—BATES BRACKET FAN MOTOR.

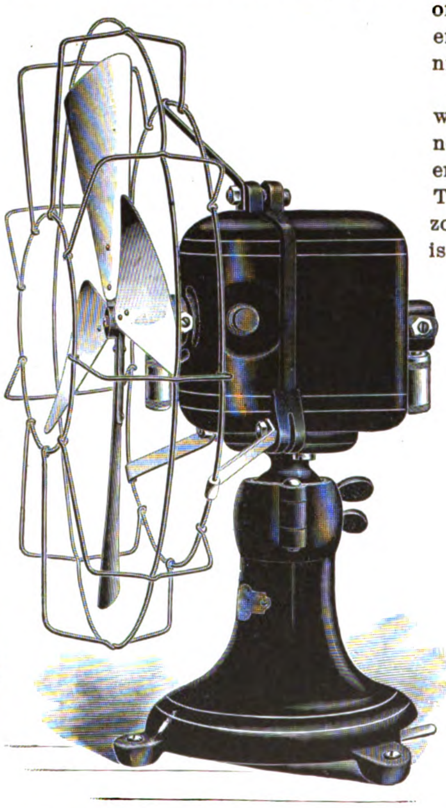


FIG. 57.—DIEHL DESK FAN MOTOR.

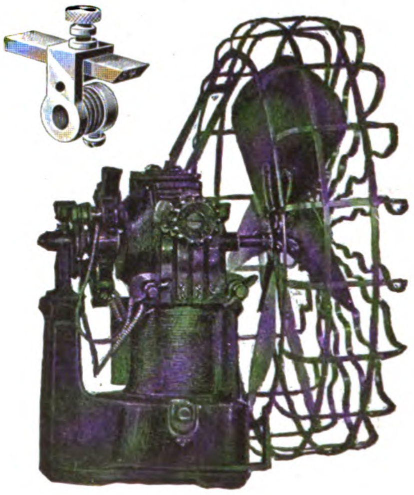


FIG. 58.—CROCKER-WHEELER FAN MOTOR.

Still another desk motor of the same general outline as the two last described is the Diehl, Fig. 57. This differs from the preceding motors in that the magnet shell is made in two sections, one containing the poles and rear bearing, and the other containing the front bearing and serving to complete the yoke shell. This construction eliminates the use of separate journal caps or rings. The two sections are secured together by a bolt at the top and two at the bottom of the structure. These machines are equipped with a ball-and-socket joint which allows them to be adjusted for either desk or wall service. The Diehl ceiling fan motor, Fig. 54, is of the same design as the desk motor, being merely wound for slower speed and adapted mechanically to run in the changed position. The armature may be removed by taking out three screws, without disturbing the body of the machine.

In the Bates bracket fan motor, Fig. 56, an inverted horse-shoe field magnet of drop-forged steel is used. The armature is closed in by shields fitted to the field-magnet pole pieces. The armature is drum wound in slots and the bearings are of bronze, self-aligning and fitted with automatic compression oil cups. These fans are made 12 and 16 inches in diameter, furnished in either desk or bracket form, and provided with a ball-and-socket joint to permit adjustment to any angle of "aim." The motors are wound for either 110 or 220 volts, and have three running speeds.

Another desk and bracket motor in which an inverted horse-shoe field magnet is employed is the well-known Crocker-Wheeler machine, shown by Fig. 58. The armature is ring-wound, in trapezoidal slots, and the brush arrangement is the pivoted clamp holder type used on large machines and shown also in Fig. 58. Speed regulation is effected by varying the field-coil connections; the coils are connected in series for moderate speed, and thrown into parallel to give the maximum speed. These motors are also furnished mounted on a wall bracket, with adjustment for varying the direction of the air stream.

A fan blade designed to eliminate the buzzing by which the existence of even a hidden fan motor is usually betrayed, constitutes one of the features of the Crescent fan motor represented by Fig. 59. This motor is of the bipolar enclosed type and, like the preceding one, is convertible into a pedestal machine by adjusting the swivel joint between the motor and the bracket. The brushes are carbon pencils of the type previously described, and a rheostat in the base gives three running speeds. The Crescent ceiling fan motor of the same make is shown by Fig. 60. The armature is drum wound and the commutator is accessible upon raising the shield over the top of the motor.

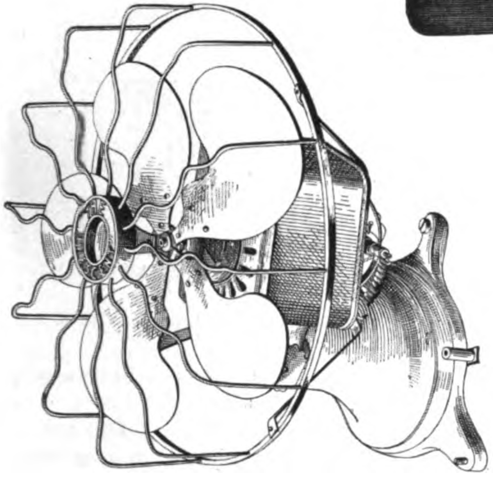


FIG. 59.—CRESCENT BRACKET FAN MOTOR.

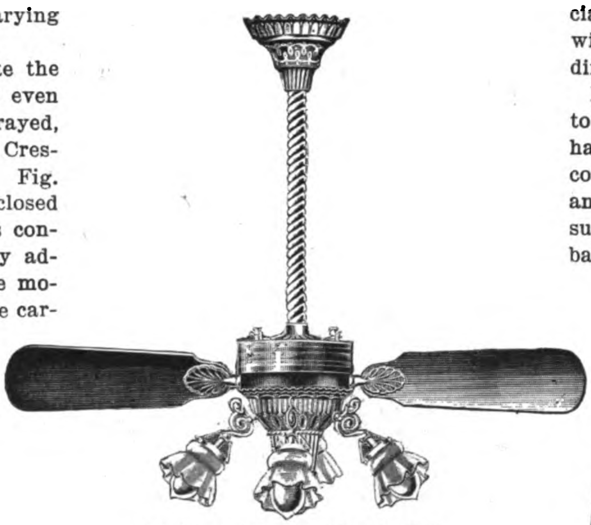


FIG. 60.—CRESCENT CEILING FAN.

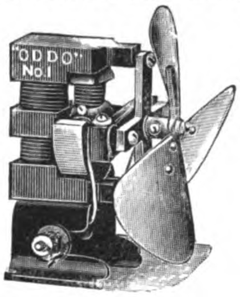


FIG. 62.—ODDO FAN MOTOR.

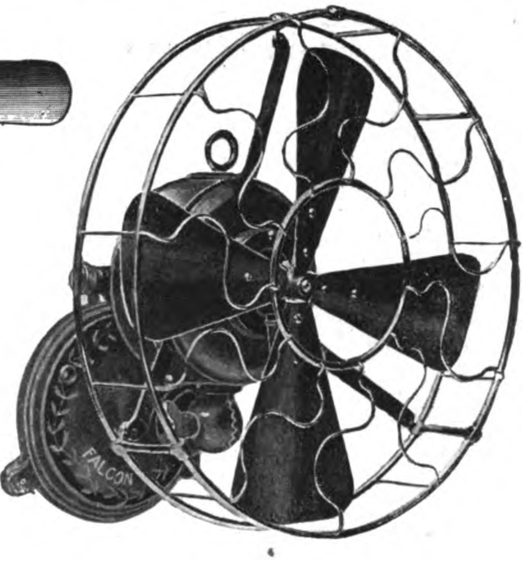


FIG. 61.—FALCON BRACKET FAN MOTOR.

The Falcon fan motor, shown by Fig. 61, is a combined desk and bracket machine. The motor is secured to the pedestal by means of a ball-and-socket joint, allowing adjustment to any angle within a wide range. The pedestal is provided with screw holes so that it may be converted into a wall bracket at pleasure. The wires leading into the motor enter beneath the pedestal or base and pass up through the ball-and-socket joint, so that no wires are visible around the motor. The motor is built for continuous-current circuits of 115 and 230 volts and also for battery circuit. It is completely enclosed except for a few radial slots in the end caps near the bearings for ventilation. Self-feeding carbon brushes and self-oiling bearings are provided. Three speeds are available by means of resistance coils and a switch in the base. The current consumption at maximum speed is as follows: 115-volt 12-inch fan, 0.45 ampere; 16-inch, 0.6 ampere; 220-volt, 12-inch fan, 0.25 ampere; 16-inch, 0.33 ampere.

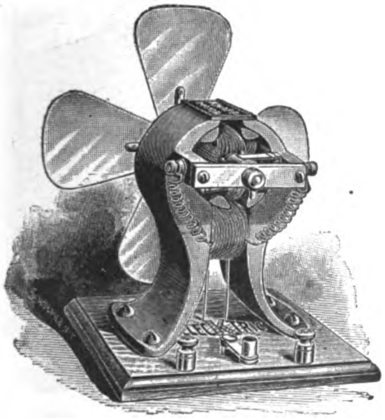


FIG. 64.—KNAPP BATTERY FAN MOTOR.

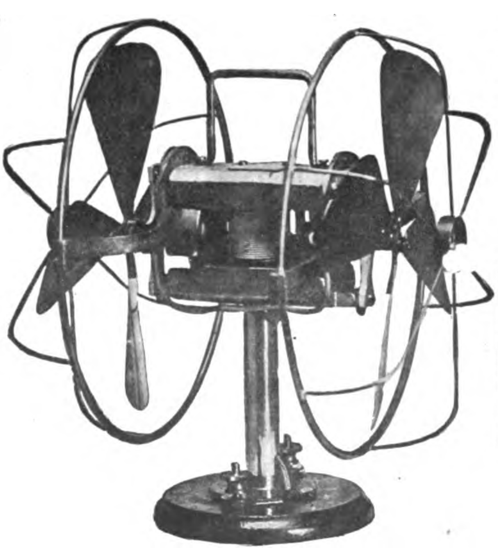


FIG. 63.—ODDO DOUBLE-FAN MOTOR.

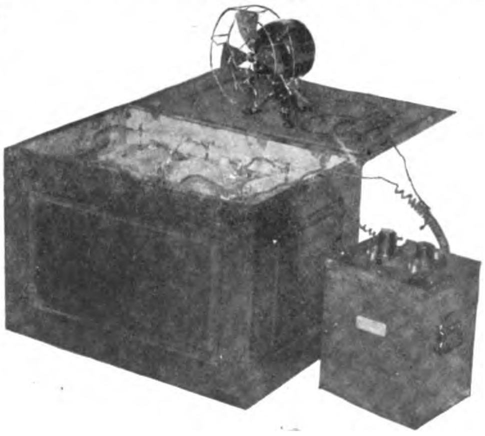


FIG. 65.—EXCELLO BATTERY FAN OUTFIT.

A compact little battery motor, known as the "Oddo," is shown by Fig. 62. The motor has a three-pole three-coil armature which makes 1800 revolutions a minute with one cell of battery. The battery is a bichromate of potash cell, a modification of the old Grenet electropoion type. The charging solution is 1½ pints of water, four ounces of bichromate of potash and ¼ pint of sulphuric acid (commercial). The "Oddo" motor is also furnished with two fans, throwing air in opposite directions, as shown by Fig. 63.

Fig. 64 shows the Knapp battery fan motor, known as "Type C." The armature has six projections or teeth and has a six-coil Siemens winding. This motor drives an 8-inch 4-blade fan at 1800 r.p.m. when supplied with current from three cells of battery. The battery is a carbon-zinc primary cell and is encased in a convenient wooden cabinet.

Fig. 65 represents a larger battery fan motor, known as the "Excello," together with a complete outfit of two storage-battery cells in a single case, and a charging battery of six "Excello" gravity cells. The motor is of the bipolar "ironclad" enclosed type and drives an 8-inch fan at 1500 revolutions a minute. A single long bearing is used, and this is equipped with automatic oil feed. Access to the brushes and commutator is afforded by a removable cap on the back part of the enclosing shell. The charging gravity battery is a modification of the Daniell type, being provided with a central porous cup which contains water and the zinc electrode. The copper electrode is a split cylinder surrounding the lower end of the porous cup and provided with legs of strip copper which bury in the blue-stone crystals at the bottom of the cell. The gravity batteries are connected permanently to the storage cells, which are thus charged during each interval of idleness at the fan. The outfit shown by Fig. 65 will run three hours a day for about four months without any attention beyond drawing off about three-fourths of the liquid in the porous cup and replacing it with clean water once a month. At the end of four months the gravity-battery cells require a general replenishing.

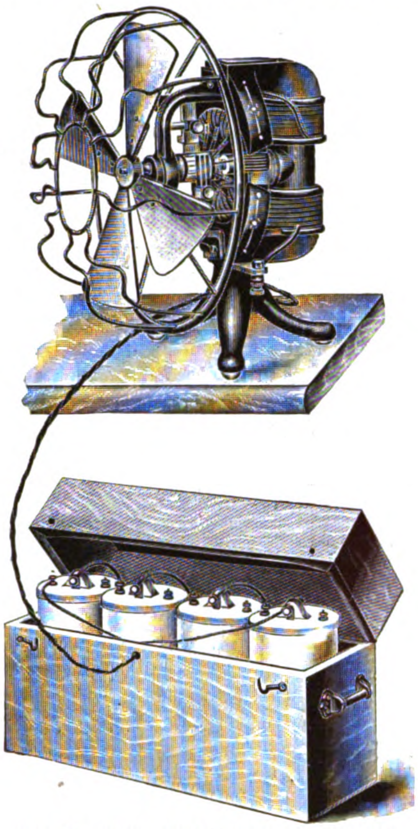


FIG. 66.—EDISON BATTERY FAN OUTFIT.

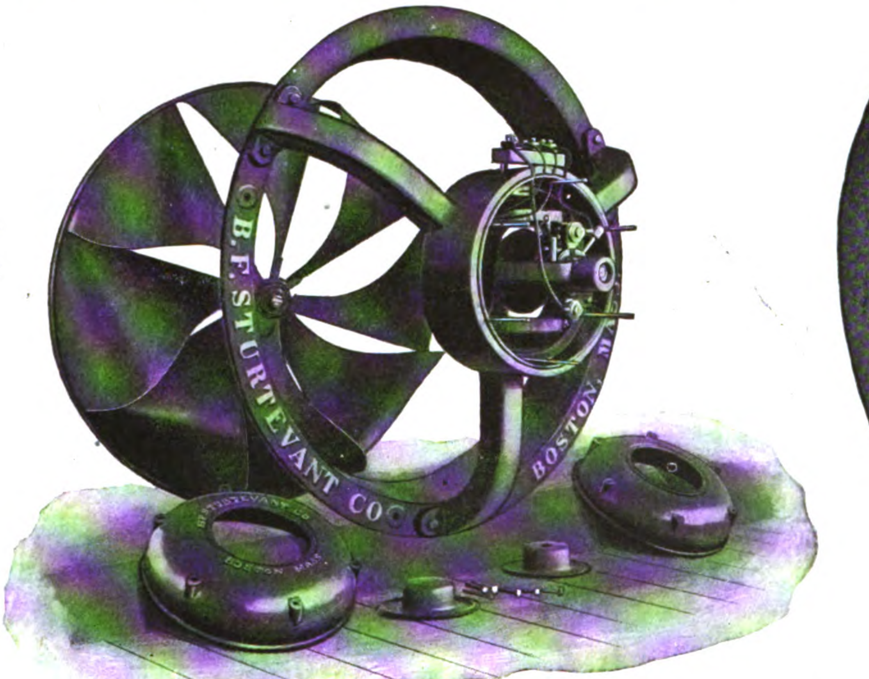


FIG. 67.—STURTEVANT VENTILATING FAN OUTFIT.

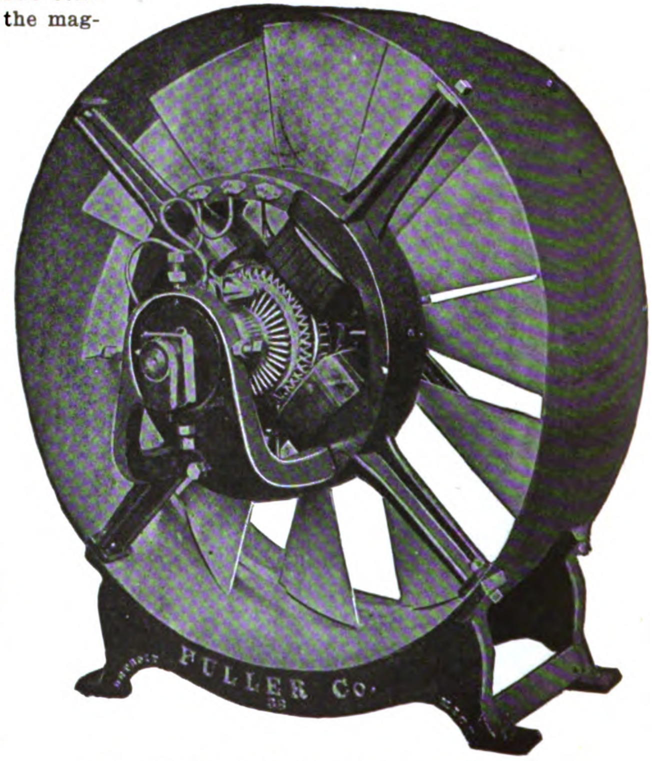


FIG. 70.—FULLER VENTILATING FAN OUTFIT.

The Edison battery motor, Fig. 66, is provided with a Gramme ring armature of conventional construction, a copper commutator insulated with mica, and spring brush holders. The battery is the well-known Edison-Lalande, and the fan is 9 inches in diameter. The motor has been made more economical this year by tapping the field-magnet winding for speed regulation. The armature runs in ball bearings.

A compact ventilating outfit is the Sturtevant, shown by Fig. 67, which shows plainly the method of mounting the motor on the fan casing. For fans up to 54 inches diameter the motor is of the bipolar type illustrated. The field-magnet ring or yoke carries a thin circular flange on each side to enclose the field coils and afford a seat for the end caps shown lying on the floor in the illustration. Fig. 71 gives a cross-sectional view of the field ring alone. Each magnet core is integral with its pole shoe and is bolted to the central web of the yoke ring. The coils are form wound and slipped on the magnet cores before the latter are bolted in.

The journal yokes are arranged ingeniously. Fig. 68 shows the cradle formed by the yokes, with the armature in position. The flanges on each side of the armature brace the central web of the field ring to which they are bolted, at points midway between the magnet poles. The brushes are carbon, of the reaction type. The journals are provided with composition sleeves or bushings, which may be removed from the outer ends of the boxes without disturbing the other parts of the machine. The motor is entirely enclosed, the central openings in the end plates being covered by the little hat-shaped shields shown in Fig. 67. These motors are built for a maximum rise of temperature of not over 60 degrees F. for a 10-hour continuous run.

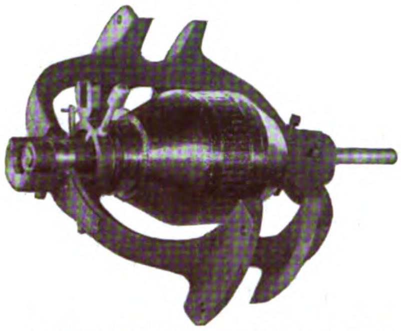


FIG. 68.—STURTEVANT JOURNAL YOKE.

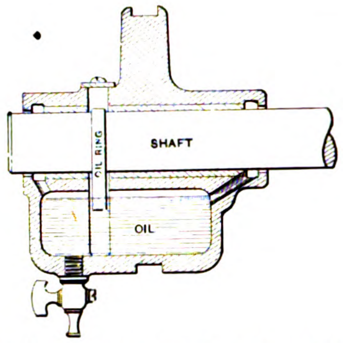


FIG. 69.—DETAILS OF FULLER BEARING.

The fan blades are of propeller design, gradually assuming a helical shape toward the outer or delivery edges. The air is picked up at a low velocity and accelerated in its passage from the inner to the outer edges of the fan blades. These outfits are built in sizes ranging from 18-inch to 120-inch fans, and for use on 115, 230 or 500-volt continuous-current circuits.

The principal feature of the Fuller ventilating fan shown by Fig. 70 is the shape of the blades. Each blade is a segment of a screw thread; that is, if a blade were widened sufficiently to complete a circle about the shaft, it would be a perfect screw thread of one turn. The object of this design is to handle a given volume of air at a lower speed in order to eliminate the buzzing due to the impact of the blades against the air.

The motor field-magnet ring has four radial arms or spokes cast on its periphery, by means of which it is bolted to the fan casing. The armature coils are form wound, drum winding in slots being used. The brushes are carbon, of the reaction type, so modified as to allow the motor to be run in either direction. The bearings are of the ring-oiling type, shown in cross-section by Fig. 69. The journal bushing in fans up to 84 inches in diameter is rigid, as shown here; fans larger than 84 inches have the familiar self-aligning type of bearing. The oil rings in all of the bearings are notched in order to increase their oil-carrying capacity.

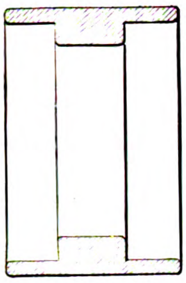


FIG. 71.

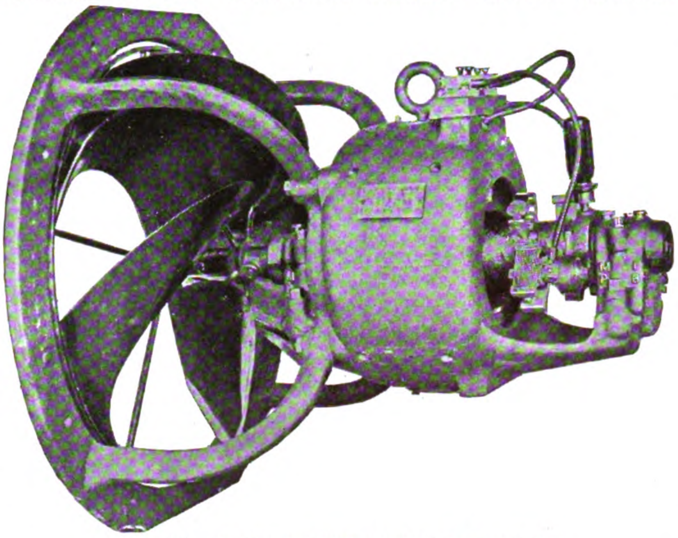


FIG. 72.--WAGNER VENTILATING FAN OUTFIT.

A somewhat similar shape of fan blade is used in the Wagner ventilating outfit shown by Fig. 72. The motor is the standard Wagner continuous-current machine. The arms by which it is attached to the fan rings are cast integral with the ring and bolted to the motor shell. These motors have the unusual number of 12 running speeds and range from ¾ h.p. on a 24-inch fan to 10 h.p. on a 60-inch fan. The normal running speed is from two-thirds to four-fifths of the maximum speed of which the motor is capable. Rheostat control is used exclusively for all motors except the 5-h.p. and 10-h.p. sizes, which drive 48-inch and 60-inch fans; these motors are regulated by rheostat up to the tenth speed; the highest three speeds are obtained without any dead resistance, by field commutation.

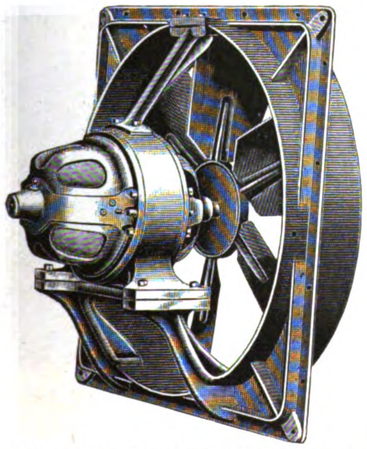


FIG. 73.—TRIUMPH VENTILATING FAN OUTFIT.

The Triumph ventilating outfit, shown by Fig. 73, comprises a multipolar enclosed motor direct-connected to the fan, and mounted on a bracket which is cast integrally with the fan frame. The motor is of standard modern design, shunt wound, and its speed is regulated by means of a rheostat in the armature circuit.

ELECTRICAL EQUIPMENT OF THE CHICAGO GREAT WESTERN RAILWAY SHOPS.

Following the numerous examples set by machine shops and industrial establishments generally, the Chicago Great Western Railway Company in its new shops at Oelwein has made electrical apparatus the means of securing compactness, flexibility and convenience as well as economy of operation. The transfer of both raw material and finished product is accomplished by means of an electrically-driven transfer table operated by a G.E.-52 motor, which takes current from two overhead wires; this transfer table is capable of carrying the largest coach and the heaviest locomotive used in railway practice. The tools in the machine shop are driven by motors, and in this same department is a large electrically-driven crane; in the store house is an electrically-driven elevator and an electric derrick. The boiler shop tools are driven electrically; the blacksmith shop is equipped with electrically-driven blowers for the forges, etc.

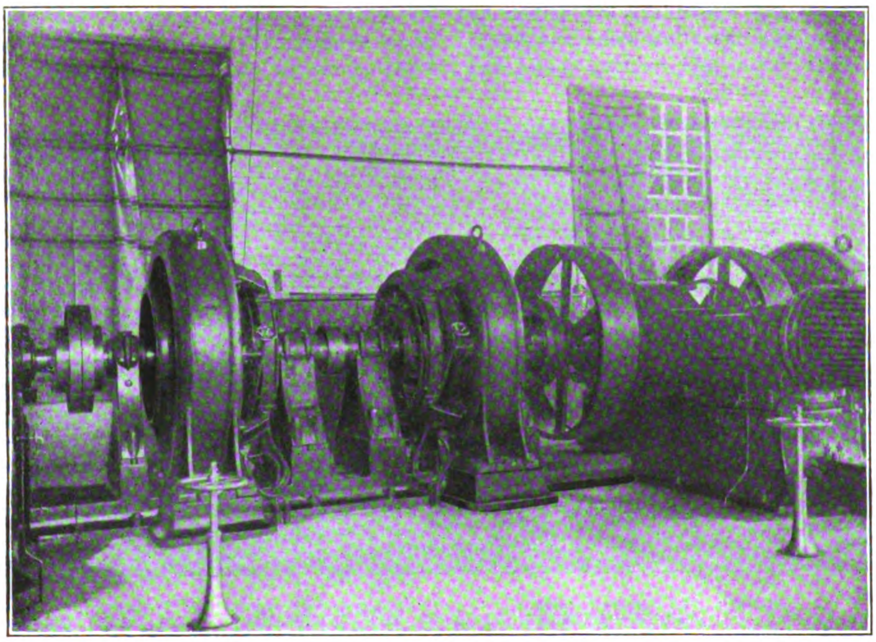


FIG. 1.—ONE ENGINE AND TWO OF THE GENERATORS, "QUILL" CONNECTED.

The power house has a basement which connects by tunnels with the different shop buildings. These tunnels are used for the heating, compressed-air, live-steam and water pipes, and for the electric wires of the power and lighting circuits. The generating plant consists of three 100-kw. Crocker-Wheeler machines, driven by two tandem-compound Ideal engines (A. L. Ide & Son) through the medium of the Arnold transmission system of quills and magnetic clutches. Fig. 1 is a view in the engine room, and Fig. 2 is a sectional elevation of the engine and boiler rooms. The engines and generators run at 250 r.p.m. One of the engines has sufficient capacity to drive two of the generators, and the other one is half this size. The smaller engine, however, is provided with an auxiliary steam connection which permits live steam to be admitted to the low-pressure cylinder through a reducing valve, thus furnishing means of carrying an overload of 100 per cent. in an emergency, the mechanical features of the engine being designed with this in view. The steam consumption specified by the contract for the engine is 44 pounds per kilowatt-hour at full generator load; 54 pounds at three-quarter load, and 72 pounds per kilowatt-hour at half load. This is for the large engine driving two generators.

The boiler plant comprises three Stirling boilers, put in under guarantee to evaporate eight pounds of water into steam containing not more than 3 per cent. moisture, from and at 212 deg. F. per pound of lump coal burned, with a draft of 0.6 inch at the base of the stack. This requirement is based on coal having a calorific value of 11,500 B. T. U. per pound. The exhaust steam from all sources is passed through oil extractors and used for heating the buildings, and the condensation forms part of the boiler feed water, which is required to be delivered to the boilers at 200 deg. F. or over. This arrangement was considered preferable to the use of condensers because the cost of fuel is very low and the shops require to be heated during at least five months in the year, the heat required being considerable. The vacuum system of the Western Paul Company is used for the purpose of relieving the engines of back pressure during the heating period.

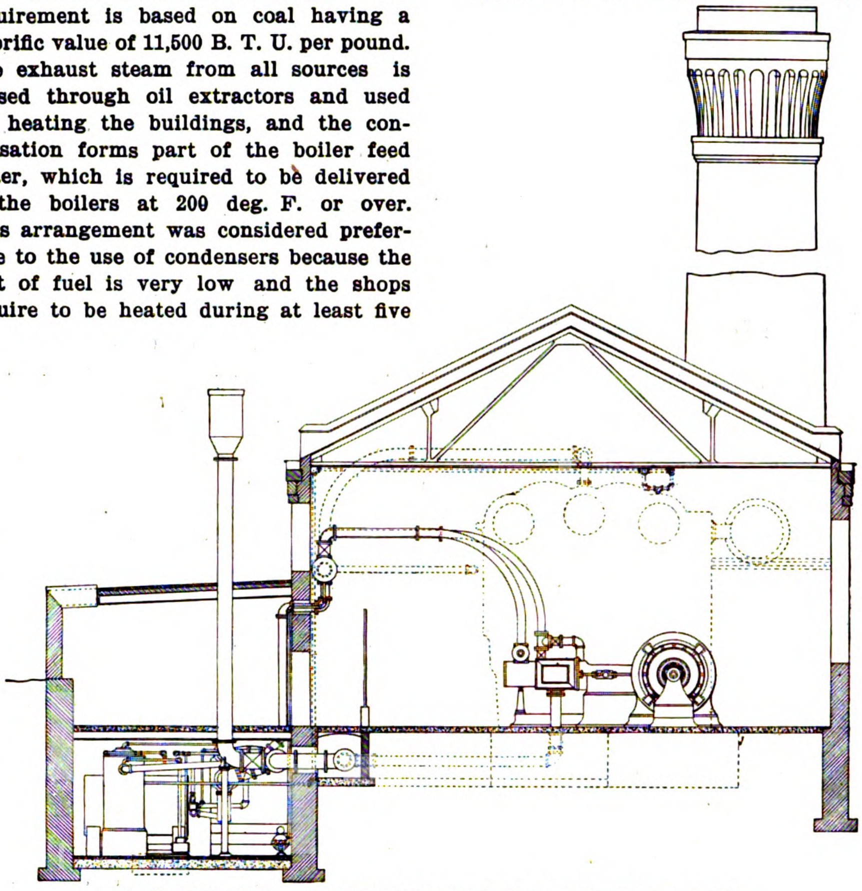


FIG. 2.—VERTICAL CROSS-SECTION THROUGH THE POWER HOUSE.

All tools and machinery are driven by electric motors excepting some pneumatic tools in the boiler and erecting shops, and the air lifts. The contract requires that the motors shall deliver their rated output for 18 hours a day, with an average efficiency for all sizes of not less that 88 per cent. at full load, 86 per cent. at three-quarters load, and 83 per cent. at one-half load. The motors to be capable of carrying 25 per cent. overload for two hours without injury and in starting to be able to develop 50 per cent. more than the rated output.

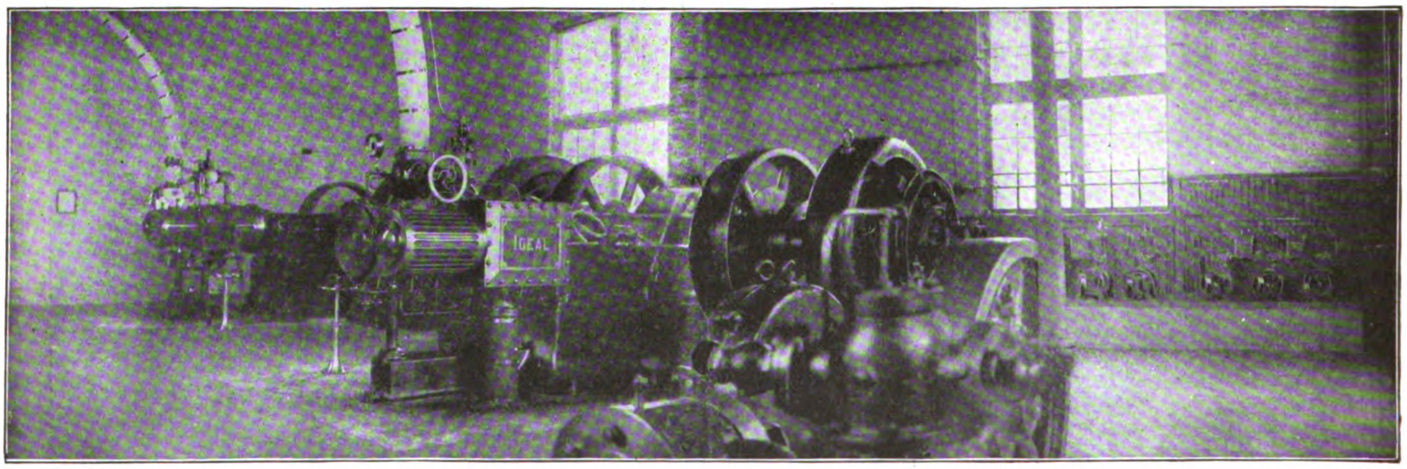


FIG. 3.—ANOTHER VIEW OF THE GENERATING UNITS. AIR COMPRESSOR IN THE FOREGROUND.

Current for both motors and lamps is supplied at 220 volts, 600 16-c.p. incandescent lamps of that voltage being used. There are also 51 arc lamps of 1200 c.p. each. Fig. 3 is a view of the switchboard. Each generator is provided with an individual panel, as usual; the third panel contains the circuit switches. The lighting circuit feeders are controlled by the two double-pole switches, and the power-circuit feeders by the three upper switches. An unusual feature of the board is that there are three bus-bars, one positive for the lamp circuits, one positive for the motor circuits, and one negative bus-bar common to both sets of feeders. The single-pole switches shown are for connecting the two positive bus-bars when it is feasible to supply all the service from a single generator or pair of generators.

Thirty motors, varying in size from 2 to 60 horse-power, are used in the shops. All of these are Crocker-Wheeler machines except the General Electric motor on the transfer table and the motors on the machine-shop crane. The crane, which has a capacity of 15 tons, was furnished by Manning, Maxwell & Moore. It has a span of 60 feet, covering the whole of the main machine shop. In this shop the tools are divided into two groups, so far as power distribution is concerned, being belt driven from two line shafts, each 75 feet long. Each line shaft is driven by a 20-h.p. motor, and the two shafts can be coupled by means of an Arnold magnetic clutch when it becomes practicable to drive both by a single motor.

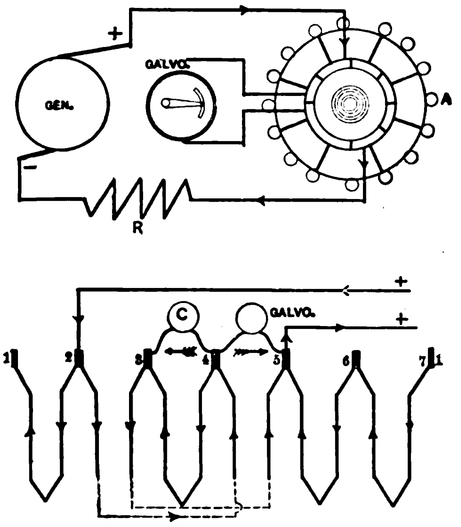
The boiler-shop tools are belt driven from a single line of shaft, similar to that in the machine shop, and driven by a 20-h.p. motor. In the wood mill, where the bulk of the power is used, all of the motors are supported above the purlines of the trusses, leaving the spaces underneath free for shafting and belts. Each of the five shafts in this mill is driven by an individual motor. In this mill, the Arlington Curtis Company installed a system of collectors for removing the sawdust and shavings from all the machines and delivering them to the boilers in the power house.

The blacksmith shop is equipped with down-draft forges, blown by Sturtevant fans, which are driven by a 25-h.p. motor. A 10-h.p. motor in this department drives a small steam hammer, a punch and shear and a forging machine. Smaller motors drive the shafting in the wheel shop, the ventilating fan in the lavatory, the hoist in the ice house, and a pump under the water tank. The use of motors in the yard operations will be extended by equipping the turntable, the coal chute and prospective labor-saving apparatus.

The entire equipment was furnished by the Arnold Electric Power Station Company of Chicago.

Among our Foreign Contemporaries

Localizing Defects in Drum Armatures.—A recent issue of the London "Electrical Engineer" contains two communications describing methods for localizing defects in drum armatures, adapted for use in repair shops. Although there is nothing new in these communications, they are of interest, as the methods described are practical, and seem to be well arranged. The first test should be made for an insulation breakdown, with double the running volts of the armature, either direct or alternating, first from commutator to spindle, then from each armature band to commutator. Then tests should be made for a short circuit, for loose or badly connected joints, for a broken circuit, for cross-coupling, and for unequal conductivity of copper. A direct current is passed through the armature from side to side, as shown in Fig. 1, with a variable resistance in series, and the drop is measured across adjacent segments with a high resistance low-reading galvanometer; if a Weston millivoltmeter is used, a very few amperes are sufficient to give a good deflection. If a coil gives no deflection, it means a short circuit. If certain coils give much higher deflections than others, it points to loosely connected end connections or badly sweated joints. A fault causing trouble in large armatures, where stranded or made-up conductors are used, is that these bars sometimes vary in their relative resistances, and when being tested show a variation in the galvanometer deflection of perhaps only 1 to 2 per cent. When a fault of this kind is found, it is advisable to attach the galvanometer leads to a pair of sharp pointed awls, which can be pressed through the insulation of the bars at each end without doing any damage, and the relative drops across each bar can thus be taken independently of end connections. In the case of a broken circuit the current passes round one side of the armature but not the other; if by mischance the coil with a broken circuit is attached to the segments first bridged by galvanometer, the full voltage of the circuit would be put across the instrument; a light fuse should therefore be attached to the galvanometer. Wrong couplings may be found by this method in certain cases, but not if the fault consists of a simple cross coupling. A case in which the method under discussion enables one to find a wrong coupling is sketched in the second figure, which shows the couplings of a drum armature spread out flat, with a wrong coupling shown by dotted lines, the current entering at commutator segment 2 and leaving at 5. If the fault consists of a simple cross coupling, as shown in Fig. 2, it cannot be located by this method, and a bottle of glycerine and iron filings must be resorted to, which, if laid along each conductor while carrying current, will show the direction of flow. Sometimes an armature is sent in for repairs, and there is no field in which it can be run before sending it out again; then the armature may pass the galvanometer test, but break down the first time it is run, owing to insufficient insulation between conductors. This difficulty can be overcome by passing a low-tension alternating current through the armature with variable resistance in series. The armature acts as a sort of choking coil, and if a suitable current is put through, and it is not designed for a machine of excessively high speed, it can be made to choke back the terminal pressure for which it is designed, which is equivalent to running it in its own field.



FIGS. 1 AND 2.—ARMATURE TESTING,

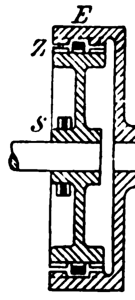


FIG 3

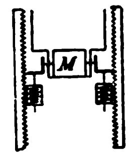


FIG. 4.

Electric Hoisting Apparatus.—In recent issues of the "Elektrotechnische Zeitschrift" Dr. F. Niethammer contributes a long and well illustrated article on electric generators and motors for hoisting apparatus, which is a rather full account of the present European and American practices. Single-phase alternating current motors should not be used for hoisting purposes. The three-phase motor is in most respects as good as the direct-current motor or even better, especially mechanically. Nevertheless he prefers the direct-current system to the three-phase, on account of the easy regulation and the possibility of using an accumulator. He recommends compound wound generators for a smaller installation, and shunt dynamos for a larger network with accumulators. Of the different direct-current motors the series motor is said to be the best for all lifting apparatus, where there never can be no load at all. The shunt motor can be recommended only in such installations where for any load a very constant number of revolutions is required or where a case of there being no load can occur by balancing one load against another, as in balanced elevators. Of the numerous special apparatus described by him, the following may be of special interest. Fig. 3 shows an electromagnetic coupling; both parts have toothed poles which are excited by a common coil, slippage without friction being therefore possible at start or at overload. The speed of electric elevators is in Europe scarcely more than 6½ feet per second, while in the United States speeds of 10 or more feet per second have now come into use. The speed of hoisting machines is from 10 to 50 feet per second. A peculiar and very simple construction of a freight elevator of the Oerlikon Company is illustrated in Fig. 4. The motor, which is fixed on the platform, drives two toothed wheels or two worms which gear into two stationary vertical racks in the elevator shaft, so that the platform climbs, as it were, up along these racks.

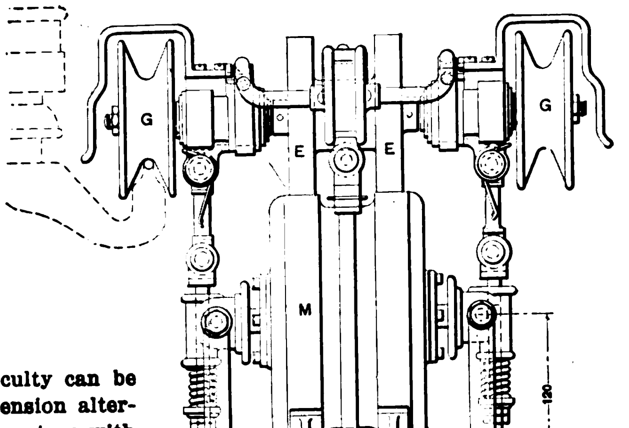


FIG. 5.—TROLLEY MOTOR.

A Novel Automobile System.—The suggestion to supply electrically-driven vehicles from overhead trolley wires is by no means new, and the obvious limitations of such a system have discouraged even preliminary experiments in this country. In France, however, M. Lombard-Guerin has demonstrated the courage of his convictions by establishing an experimental trolley-automobile line, at least two features of which are distinctly novel. The overhead line is double, of course, and sustains a carriage, or duplex trolley, connected to the vehicle on the ground by a flexible cable, and shown by Fig. 5, page 179. The line runs along the left bank of the River Seine, from the gates of Paris to Issy, a distance of about 3200 feet, substantially parallel to the roadway. The overhead carriage or trolley constitutes one of the novelties of the system. It consists of a three-phase induction motor, M, Fig. 5, suspended in a framework from two aluminum grooved wheels, G, G, to which it communicates motion through the medium of friction rollers, E, E, the rotor of the machine being the outside member. The trolley is not in electrical connection with the line, but derives its current from the motor on the vehicle. This motor is a series-wound continuous-current machine, which receives constant-potential current from the line at 220 volts. The armature is equipped with three collector rings tapped to the winding at 120-degree intervals, and the little motor on the trolley is supplied with three-phase currents from these collector rings. The power motor is thus a rotary converter, receiving continuous current and delivering alternating. It is obvious that the frequency of the three-phase currents delivered to the trolley motor varies with the speed of the automobile motor, so that the trolley automatically maintains a speed corresponding to that of the vehicle. The motor on the vehicle is controlled by a rheostat in simple series with its field and armature circuits.

New Double Break Single-Pole Switch.—An interesting method of separating the contacts of a double-break jaw switch, which is used on the London Central Railway, is described in a recent issue of the "Engineering Times," and represented by Fig. 6 herewith. As the figure clearly shows, the two switch jaws are mounted on opposite sides of an insulating panel and the switch arms are connected at the pivot ends by copper leaf. The operating rod, A, carries a slotted end-piece which engages with a pin in the end of the bell-crank lever after the coiled spring, S, has been brought to full tension. This arrangement obviously secures the quick break which has characterized smaller switches used in this country for several years. The switch levers are provided each with a gear segment concentric with its pivot, the two segments meshing, as shown by the illustration, in order to secure unanimity of movement.

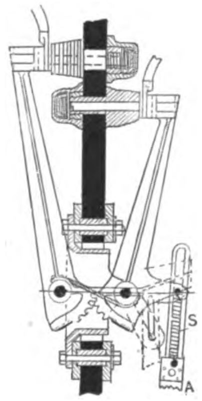


FIG. 6.—NEW DOUBLE-BREAK SWITCH.

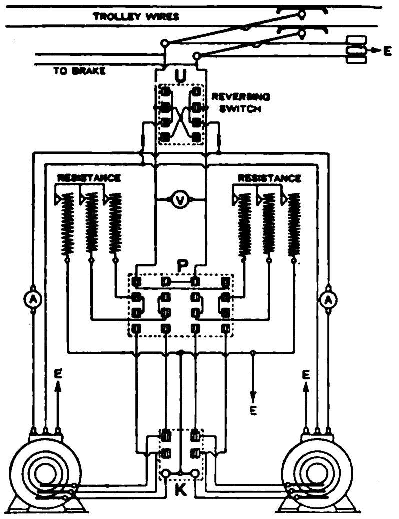


FIG. 7—JUNGFRAU LOCOMOTIVE CONNECTIONS.

Three-Phase vs. Continuous Currents for Railways.—The trip which the British Institution of Electrical Engineers made to Switzerland last autumn, and the report of the Swiss Visit Committee to the Institution aroused a long and extended discussion on Swiss electrical engineering at two meetings. The main feature of this discussion, which was printed in the London technical papers, was the comparison between continuous and three-phase currents for traction work. The same question was discussed afterward in several communications published in the columns of the London "Electrician." It appears that there exists great difference of opinion. While a considerable number of able engineers refer to the excellent work of the three-phase motor on Swiss mountain railways, and express a desire that the polyphase system be introduced in Great Britain for traction purposes, more conservative engineers agree that a three-phase trolley line may be eminently suited for lines on which the stopping places are few and far between, and in localities where crossings and junctions are not numerous, but claim that the success of the three-phase motor on such lines does not indicate its suitability for British underground railways or street-car networks. They say that for urban work generally, the continuous-current series motor appears best, and if three-phase transmission is desirable, rotary converters or motor-generators should be used. They base this opinion upon considerations of the velocity-time curve between starting and stopping, which should be peaked and not flat for economy in ordinary tramway work, so that a three-phase motor would continually run very inefficiently. Mr. E. K. Scott refers to the alleged complication of switching arrangements and of the gearings on the Jungfrau three-phase locomotive, in a communication to the London "Electrician." He points out that perhaps at first sight the locomotive has the appearance of being complicated, but as a matter of fact, when the different parts of the gear are analyzed, a three-phase locomotive appears to be more than usually simple. He then gives, side by side, an ordinary car wiring diagram, with controller for two 30-h. p. continuous-current motors, and the connections for the rheostatically controlled Jungfrau three-phase locomotive. The latter is reproduced here as Fig. 7. He calls special attention to the absence of any arc-suppressing device as a distinct advantage of the three-phase traction motor. The arcing that does occur is at a low voltage and very feeble, due possibly to the short air-gap of the motors and the fact that the magnetic circuit is built wholly of soft steel plates like a transformer. The rheostatic method of control permits of an extremely regular and, therefore, a rapid, acceleration, and there is no liability to jerking, as is often the case in changing continuous-current motors from series to parallel.

Electric Telpherage in Office Buildings.—In a recent number of the "Zeitschrift fuer Electrotechnik" of Vienna, a simple trolley system for office purposes is described, which is used with success in the offices of a German insurance company. On a small car, driven by a 1-10-h.p. motor, is suspended a case or box containing the papers, letters, etc., to be transported as shown in Fig. 8. The axle to the right in the illustration is provided with a toothed wheel which is driven by the motor. The current is supplied by a bare copper wire, and the return current goes through the wheels and rails. The car is provided with a commutator, to reverse the current. The car runs at a speed of 3 to 5 feet per second. The ends of the track are not in circuit, and are inclined so that the car reaches the end with decreasing speed. When the car buffer pushes against a buffer at the end of the line, a hook drops into the groove in the wedge, shown in the figure above the buffer, and the car is stopped. The system appears to be well adapted for use in offices, workshops, hospitals, libraries, etc.

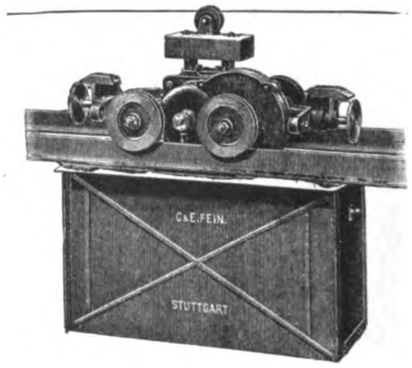


FIG. 8.—TELPHER MOTOR.

The Nernst Lamp.—Since the first notes on the Nernst lamp appeared in the technical press some time ago, the lamp has been perfected by the owners of the European patents, the General Electric Company of Berlin, to such a degree that it is now to be introduced commercially. French contemporaries announce that a large number of Nernst lamps will be exhibited at the coming Paris exposition, and a note in the "Elektrotechnischer Anzeiger" states that the lamp is being introduced industrially in Goettingen, where Mr. Walter Nernst is professor of theoretical chemistry and electrochemistry. For each lamp installed a rent of 12½ cents a month will be charged in addition to the price of the current. An alcohol apparatus for lighting the lamp will be furnished gratis; the use of matches is forbidden. Lamps with means for automatic initial heating will not be brought into commercial use yet. The principal claim which has been made for the Nernst lamp is, however, fulfilled; an illuminating power of 24 Hefner candles is guaranteed with a current of about that of an ordinary 10-c.p. incandescent lamp, so that the working economy is highly satisfactory. In another recent issue of the "Elektrotechnischer Anzeiger" there is an article giving brief illustrated descriptions of different forms of the Nernst lamp, taken from patent specifications which have just been published. Fig. 9 represents the simplest form; g is the incandescent body and directly below it there is a hole in the globe to allow the initial heating by the alcohol apparatus; b, b are holes allowing the heated air to escape. The ends of the incandescent body are fixed on platinum wires melted into a glass rod, f; the stiffer wires, h, are put into the tubes, e; the part, h, g, f, is, therefore, easily interchangeable. The next form of lamp described is for automatic heating; g, is the incandescent body and h the heater. When the lamp is connected to the circuit, the resistance of g is extremely high and the current passes through s, e, h, d, k (see Fig. 10); the heater, h, raises the temperature of the incandescent body, g, so that its resistance is diminished and a part of the current begins to flow through it to the solenoid, m, Fig. 10. When this current is normal, the electromagnet, m, attracts the plate, k, and the circuit through the heating body is disconnected. There are also lamps containing several incandescent bodies in parallel. They may be arranged in two different forms; either so that there is only one heater which heats one illuminating piece and this in turn heats the next one, and so on, until all the illuminating pieces are glowing at the same time; or they may be arranged so that each incandescent body is supplied with a separate heater; in this case only one incandescent body is glowing at a time; when it burns out another one begins to glow; by thus connecting five bodies in parallel lamps with a life of 2,000 hours can be made. Another interesting lamp is illustrated by Fig. 12. Here the heating is produced by an arc between the carbons L, L, L^2, E is the incandescent body. The main current goes through K, G, F, E, E^1, G^1, to the solenoids, N and P, and the terminal, K^1. In parallel with the incandescent body, E, there are the two carbons, L and L^2, which are bridged by the carbon, L^1. When the solenoid, N, is supplied with current, it attracts the iron core, M, on which the carbon, L^1, is fixed, so that L^1 is removed from L and L^2 and an arc is produced which is magnetically blown by the solenoid, P, against the incandescent body, E. When this is heated it becomes a conductor, of course, and the current through the solenoids increases so that the iron core, M, is attracted further into the solenoid, N, until the arc is blown out by the solenoid, P. The carbons are easily exchangeable; O is a spring which serves when no current is flowing to press the carbon, L^1 against L and L^2. In other lamps instead of the electro-magnetic devices for breaking the current supplied to the heating body, a thermostatic device is used, consisting of two metallic strips which have different temperature co-efficients of expansion, and which, when heated, change their shape so as to open the circuit. A simple switching for lighting the Nernst lamps by hand is also described. In Fig. 11 the levers, a, and b, are in metallic contact through g with one end of the main line. At first, the heating body, H, and the incandescent body, A, are not in circuit; when the lever, a, is turned in the direction of the arrow, the spring, d, causes the lever, b, to follow until it makes contact with the clip, e, and the incandescent body, A, is connected to the circuit. The lever b cannot turn further on account of the stop, r. The lever, a, however, can be turned until it makes contact with, f, putting the heater, H, in circuit; a further movement is prevented by the stop, h. When the heater has brought the illuminating piece to the proper temperature, the lever, a, is released and drawn back by the spring, d, so that only the incandescent body remains in circuit.

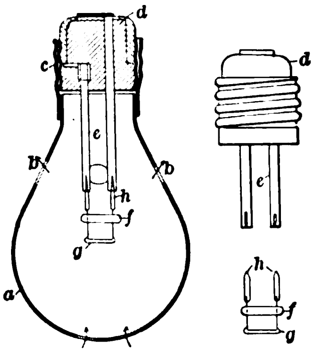
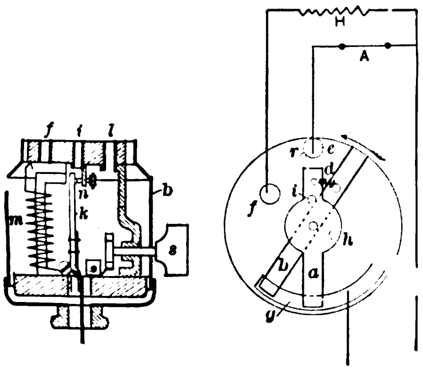


FIG. 9.—SIMPLE NERNST LAMPS.



FIGS. 10 AND 11.—NERNST LAMP SWITCHES.

Accumulator Traction.—In some of the larger cities of Germany, as in Berlin, Dresden and Hanover, a combined trolley and accumulator system has been in use for some time. While the cars are running by trolley, the current is used for both driving the electromoters and charging the batteries; in those parts of the city where the overhead line construction is not allowed the batteries supply the current for the motors. This system has been a remarkable success in Dresden and Hanover, while the break-down of the same system during the recent snowstorms in Berlin has attracted much attention and aroused a good deal of discussion. The railway companies made use of this break-down to make an attempt in the daily press to stir up the public sentiment against accumulator traction, in order to push the trolley system further into those parts of the city where it is not allowed at present. They were, however, simply advised by the police department to care strictly for uninterrupted traffic by removing the snow from the rails, etc. In an article in recent numbers of the "Elektrotechnische Anzeiger" Mr. Albrecht discusses this special break-down, and the use of accumulators for traction in general. From his remarks it appears that the main reason of that break-down was that the increased power drawn from the trolley during the snowstorms caused an unusual drop of voltage, so that the batteries were not charged fully, hence they became discharged too quickly and could not drive the cars over the accumulator zone. It thus appears that the main fault was in the power house, not in the accumulators. Furthermore he calls attention to the fact that the size of the batteries used was too small. For this reason there was much gasing and a strong smell of acid on account of an unduly strong charging

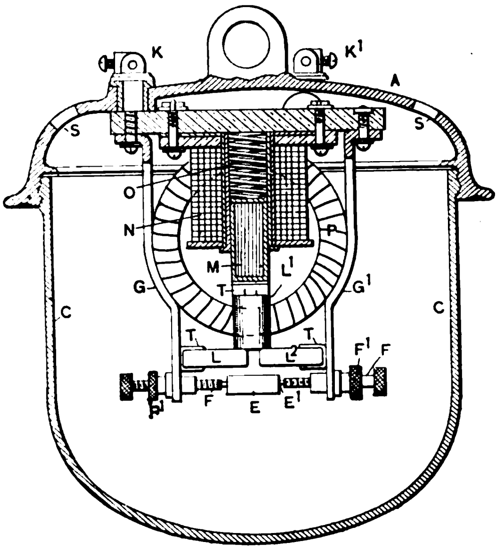


FIG. 12.—NERNST LAMP.

or overcharging at some parts of the line. Sometimes break-downs in the power house occurred which caused a stop of the whole traffic, as the capacity of the batteries was too small to supply the deficiency. He points out that these causes of stoppages do not exist in the pure accumulator system and quotes the instance of the city of Bremerhafen, where a pure accumulator system has been entirely successful. He remarks that in Dresden no such break-down occurred as in Berlin, although the topographical difficulties are greater, and calls attention to the fact that in Dresden, grid plates with active materials are used, while the Plante type is in use in Berlin. He says that in the Planté type the active material of the negative plates very soon loses its activity on account of too rapid charging with high current density or overcharging; the chemical processes combined with changes of volume occur too rapidly; as the charging and discharging takes place too quickly, there is vivid gasing and perpetual corrosion. The possibility of using larger current densities with the Planté type does not counterbalance the disadvantage of the quick decrease in capacity of the Planté type as used for traction purposes. He admits, however, that the Planté type has proved satisfactory in the combined accumulator and trolley system in Hanover.

Some Recent Electrical Patents.

The Structure of Revolving-Field Alternators.— n the type of revolving-field alternators now generally made by the Westinghouse Electric & Manufacturing Company, the whole of the magnetic circuit is made up of laminated steel, which is used for the poles and the yoke of the field as well as for the armature. The structure of this type of machine is described, and many of its combinations are claimed in a patent recently issued to Mr. B. G. Lamme. As indicated by the sections, Figs. 1 and 2, the field structure is made up of steel stampings, 6, each covering two poles, the joints between these laminations being staggered. These laminations are dove-tailed into the skeleton cast-iron spider, the centrifugal force and outward magnetic pull being taken up entirely by rim tension in the laminated iron itself. At intervals the laminations are separated by ribbed spacing plates, 7, 7, in such a way that air can pass through them and cool the iron. These spaces are set, as the cross-section, Fig. 2, shows, immediately opposite the corresponding space plates in the armature, so that each spacing ring in the field serves as a centrifugal blower for the spacing ring in the armature, the ribs of the field-spacing plates serving as vanes of the blower. To hold the field exciting coils, 10, in place, the sides of the pole tips are grooved, and there are driven in between the poles metal wedges with lips which engage these grooves and prevent the wedges from flying out radially. These wedges may have flanges to project over the adjacent spaces or tips of the pole pieces, as shown in the drawing. If so, they also serve as short-circuiting shields to check any tendency of the machines to hunt or pump when in parallel. Patent No. 633,857.

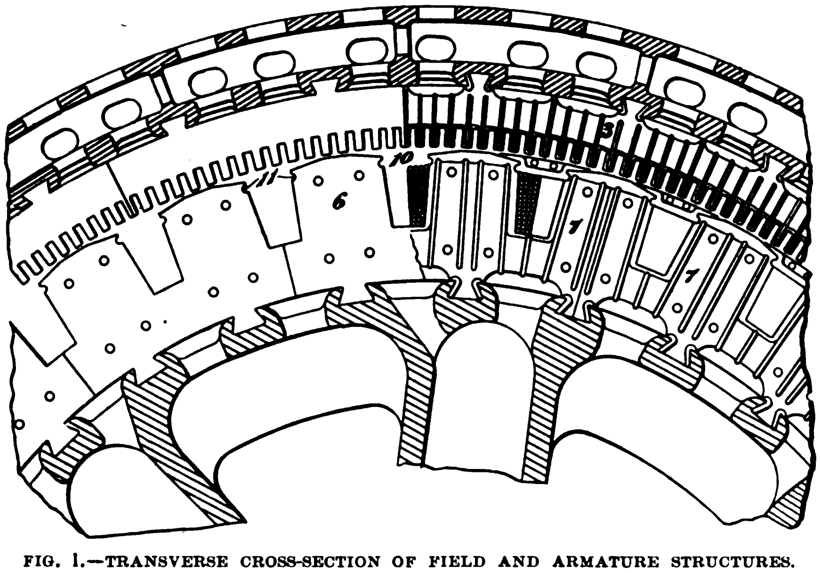


FIG. 1.—TRANSVERSE CROSS-SECTION OF FIELD AND ARMATURE STRUCTURES.

The Use of the Armoring of Interior Conduits as a Conductor.—When the neutral of a three-wire distributing system is grounded there is no reason why neutral conductors should not be exposed and uninsulated. It is foolish in such instances to make the neutral conductor a copper wire surrounded by an expensive insulating medium, in turn protected by an outer metallic armoring, when this metallic armoring itself would serve as the neutral conductor. The use of the sheathing of underground cables for the neutral has already been advocated in these columns, and there is no reason why interior conduits—provided their joints are made with sufficient carrying capacity—should not be worked in the same way. In a patent issued to A. C. M. Pruecker, of Hanover, Germany, the American rights to which have been assigned to the Siemens & Halske Electric Company, this use of the armoring of interior conduits or the sheathing of cables is broadly claimed. It is doubtful whether such claims can be held, as such a method of working must have occurred to many, and has probably been already used in some instances. Patent No. 642,627.

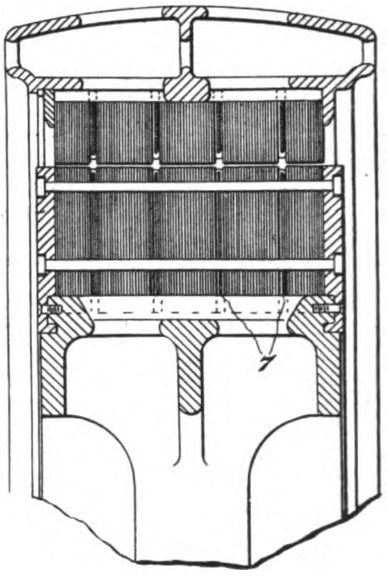


FIG 2.—AXIAL CROSS-SECTION.

Aluminum Brushes for Direct-Current Machines.—It is well known that when current passes across a joint from one metal to another there is an action the reverse of that of the ordinary thermo-electric couple, heat being liberated to a greater extent than is warranted by the ohmic resistance in case the current passes in one direction and to a lesser extent in case it passes in the other direction. Apparently this principle is involved in the action of an aluminum brush patented by Mr. Gustavos Heidel. In the specifications the inventor states that he has noticed in his experiments that the improvement shown by aluminum over other metals occurs when the brush is used on the negative side of the commutator, and does not occur when it is used on the positive side. In addition to the reduced resistance and consequent increased current-carrying capacity, the specifications state that aluminum brushes also avoid the cutting of commutator segments and the development of fine dust, which is likely to give short circuits. It is easy to understand that the naturally slippery surface of aluminum, giving a formation of lubricating oxide, might make a good commutator lubricant. The patent claims are very broad, the first one reading: "As a new article of manufacture, a negative brush for dynamos or electric motors composed of aluminum." It is obvious that the claim ought to read: "A negative brush for dynamos or a positive brush for motors." Patent No. 641,012.

NOTES.

A Mammoth Belt.—What is said to be the largest belt ever made was recently turned out by a Canadian factory for use in a grain elevator at St. Johns, N. B. The belt is of rubber, 3529 ft. long and weighs 9 tons.

An Electrically Driven Boer Shell Factory.—The London "Electrician" is authority for the statement that a Boer shell factory recently destroyed at Johannesburg, South Africa, was equipped with machinery driven by electric motors, the value of the machinery alone being estimated at $400,000.

An Automatic Police Patrol Wagon. — It is reported that the city of Akron, Ohio, has adopted the automobile for use as a police patrol wagon. The new vehicle is said to be capable of a speed of 20 miles an hour on level roads, and to have been in use for a sufficient length of time to demonstrate its fitness for the purpose intended.

License for Wiremen in the District of Columbia.—A bill has been introduced in the House of Representatives at Washington which requires all persons engaged in electrical construction or the installing of electrical wires within the limits of the District of Columbia to be licensed. The district commissioners are empowered to appoint an electrical board which will control the issue of licenses.

A Correction.—In the article by M. Georges Duchesne on "The Advantages of Superheating," which appeared in the February number of the American Electrician, typographical errors caused the names Hirn and Logelbach to be spelled Hiry and Lagelbach. The errors probably misled no one, because the name of Hirn and that of Logelbach, which he has rendered famous, are so universally well known.

The Automobile Show.—The first American exhibition of automobiles on a large scale will be held during the first week of next November in Madison Square Garden, New York City, under the auspices of the Automobile Club of American. A circular track will be provided in order to show the various vehicles in practical operation, and it is expected that some automobiles of European manufacture will be included in the exhibition.

Extension of Telephone Service to the Farm.—It is reported that telephone lines now connect merchants of Richmond, Ind., with more than 400 farm houses in Wayne County, the result being a tremendous increase in country business, not to mention the obvious convenience to the farm households. Instead of making periodical trips to the city for the purpose of making purchases, the housewife simply telephones to the stores and the goods are sent out by one of the numerous delivery wagon lines radiating from Richmond throughout the outlying country.

Free Evening Schools.—The General Society of Mechanics and Tradesmen, of New York City, announces that it has moved into the building formerly occupied by the Berkeley School at 20 W. 44th Street, this city, and has fitted up the building as school-rooms where free instruction is given three nights a week in all branches of mathematics; mechanical, architectural, free-hand and ornamental drawing. The society has an extensive library and has recently purchased a complete set of models which are, of course, accessible to the students. The course begins early in October, but application may be made any time from now until fall by calling at the school building any Monday, Wednesday or Friday evening between 7:30 and 9:30 o'clock. In order to insure registration those desiring to enter should make application as early as possible.

Tunnels for Telephone Cables in Chicago.—An independent telephone organization, called the Illinois Telephone & Telegraph Company, is excavating beneath the main streets of the Chicago downtown districts a number of tunnels to accommodate the extensive telephone system which the company expects to establish. The plans contemplate about eleven miles of these tunnels, which are horseshoe shaped, about eight feet high and six feet wide, with walls formed of concrete. The cables will be carried on racks on both sides of the tunnels, leaving a clear passageway in the center. The system of distribution from the tunnels will be via laterals to the curb line, rising to the surface under the sidewalks, thus avoiding man-holes in the streets. The tunnels are about 30 to 35 feet below the street level, and are being driven from shafts, of which five are now sunk. To keep out water the air pressure is kept within the tunnels at about 10 pounds above the atmosphere.

Proposed Extension of the Metropolitan Street Railway System. — The Metropolitan Street Railway Company, which has recently absorbed the Third Avenue system, is making plans for extensive additions to its present electrical equipment. Among the most important changes will be the substitution of electricity for the cable along Broadway, Columbus and Lexington avenues and the electrical equipment of the 8th Street horse-car line. New crosstown electric lines are contemplated in 145th Street from Lenox Avenue to Broadway and along Broadway from 130th to 175 Streets. The 34th Street crosstown horse-car line will be electrically equipped and the trolley line in 135th Street is to be reconstructed and made into a conduit system, like the present Madison, 6th and 8th Avenue lines. Within a year the mammoth power house in 96th Street will supply all of the current for the whole system, the smaller power houses to be abandoned.

Electricity Building at the Pan-American Exposition. — Elaborate designs have been completed for the Electricity Building to be erected at the exposition which is to be held at Buffalo, N. Y., next year. The designs contemplate a very handsome and commodious building. The structure is to be 500 feet from east to west and 150 feet wide, giving an exhibition space of 75,000 square feet. The south facade fronts the Mall and the north fronts the Midway. The east end is toward the massive Electric Tower and the west end faces the Grand Canal. The design of the facades shows artistic groupings. The openings of the pergola-like loggias, placed at frequent intervals, present a pleasing effect. There is at each corner of the building a low-domed pavilion tower and a double-towered entrance at the center. The entrance is spanned by an ornamental arch and supported on each side by columns. The towers also have minor entrances through them. The connecting work between the towers, the pavilions at the corners, etc., are to be brilliantly illuminated and decorated with banners and flags. The general ornamentation of the building is to be frescoes in a mixture of reds, greens and yellows.

Increasing the Efficiency of Steam Engines.—One of the recent Consular reports describes in general terms experimental work done at the Royal Technical High School, Charlottenburg, Germany, with a view to increasing the heat range of the steam engine. The method forming the subject of the experiment consists of passing the exhaust steam from an ordinary compound-condensing engine through a vaporizer built on the plan of a surface condenser and containing instead of condensing water, liquid sulphurous acid, which has such a low boiling point that the heat from the exhaust steam converts it into sulphur dioxide gas. This gas is used as a working medium in the cylinder of an auxiliary engine; leaving this cylinder the gas passes through a condenser and is pumped back through the vaporizer, thus being used over and over again without any loss except the small amount due to leakage through glands, joints, etc. The Consular report consists chiefly in an eulogy of the proposed system and some generalities based on incomplete data in which the claim is made that the range of working temperature is increased 50 per cent. This statement is apparently reckless as no data is submitted which substantiates it. The process is described as the joint discovery of Mr. G. Behrend, Hamburg, and Dr. Zimmerland, Ludwigshafen, and the report states that it was first patented in 1889. The principle involved, however, is an old one, having been familiar to engineers many years prior to the patent date specified.

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The Time of Overload and the Cost of Power.

Neither the Wright discount nor the two-rate meter gives an equitable basis for estimating the cost of and proper charges for power in the cases of hydraulically-driven plants where there are no definitely-defined constantly-recurring load peaks, but where each individual load has its own independent fluctuations. There will be found in the first article in this issue a description of an odd form of meter in use on the Niagara system and based on a factor of the load not commonly taken into consideration. The meter consists of a clock train which measures the number of hours between readings during which the load exceeds the amount contracted for. The purpose of this record is to determine whether the load runs for any great portion of the time higher than it is supposed to be, or whether any overloads that may occur are few, of short duration, and of the usual unforeseen and unintentional kind.

It is obvious that in the case of hydraulic plants where practically all costs are proportional to the amount of apparatus installed, there being no large item, such as fuel, proportional to the number of kilowatt-hours supplied, a flat rate is preferable to meter readings as a basis of charging. To determine the proper basis for the flat rate a maximum-demand indicator might be used, but would have the disadvantage of recording the largest brief overload, giving no record as to whether this overload was a single brief instance far exceeding the usual demand, or but little above the usual load. The time-overload meter can be set to record the duration of time that the load exceeds that paid for, and if this time is greater than a certain number of hours per month the number of kilowatts charged for can be increased and the meter can be readjusted to record only overloads above this new figure.

Fan Motors.

Those who read the annual fan motor article which appears elsewhere in this issue may, perhaps, be inclined to comment upon the paucity of really novel features of design or construction exemplified in the machines described. This state of affairs is far from being regrettable. On the contrary, it is due to the fact that the designs of these little motors have been so tremendously improved during the past few years that the limit has been about attained. Eccentric designs were long since "weighed and found wanting"; the enormous commercial growth of this branch of the electrical industry, on the one hand, and the strides toward high efficiency and reliability of operation on the other, have been mutually stimulative, and the result is a near approach to standardization as regards the really essential features of construction. This may be dismally disappointing to the chronic seeker after novelty (who seldom actually buys anything) but it is most gratifying to both the builders and the users of fan motors.

High Voltage Incandescent Lamps.

Two supplements to the London "Electrical Review" contain interesting statistics relating to the central stations now in operation throughout Great Britain. Notable among these is the large number of direct-current plants using 220 and 230-volt incandescent lamps. Out of some 90 stations, 39 use lamps of 220 volts or 230 volts; and two stations use the unusual e. m. f. of 150 volts at the lamps. Among the alternating-current plants, 79 in number, 27 use 200-volt lamps, most of them exclusively; the mixed voltage plants are being changed over as rapidly as possible to 200 volts throughout. The tendency toward high-voltage for incandescent lamp distribution circuits seems, at first, a little odd from the view-point of American practice. Unless the English 220-volt lamps are considerably better than those made here—which is scarcely a tenable hypothesis—it would seem that the general use of such lamps is difficult of justification.

The ordinary high-voltage American lamps have an efficiency of 4 watts per candle under normal conditions, whereas 110-volt lamps which require only four-fifths of this power are in every day service. Comparing a 110-volt three-wire system and a 220-volt two-wire system roughly, it is obvious that for the same line loss the weight of copper can be made equal. The two wires of the 220-volt circuits must be 25 per cent. larger than the outer wires of the three-wire system because the lamps require 25 per cent. more current; as an offset to this, the neutral of the 110-volt system can be made one-half the area of each outer wire, giving the same total weight of copper. At the station the 110-volt system will require twice the amount of switchboard apparatus, and will also require means for maintaining the balance, preferably a motor-dynamo. On the other hand, the 220-volt system will require 25 per cent. larger boilers and engines, and the generator output will certainly equal if not exceed the combined output of the

220-volt generator and the motor-dynamo of the three-wire system. Without considering a concrete case in detail it is evident that only an abnormal condition of operation, such as free or ridiculously cheap fuel, could warrant the slight simplification of apparatus afforded by a two-wire 220-volt system at the expense of heavier equipment and greater power development than are required by a three-wire 110-volt system carrying the same number of lamps.

The foregoing conclusions apply almost as well to any multiple-wire system in which the e. m. f. from wire to wire is the basis of consideration. Even where the three-wire system is to be used, it would seem advantageous to insert a middle wire in between the neutral and each outer wire rather than use 220-volt lamps. The strong point in favor of the latter, however, lies in the fact that an existing three-wire 110-volt distribution system may be made to supply about three times its present number of lamps, with the same percentage line loss, by changing the voltage between wires from 110 to 220 and enlarging the power plant accordingly. If the lamps were of equal efficiency, the change would exactly quadruple the permissible distribution at fixed line loss; and if the 110-volt lamps used were of 3½ watts efficiency, then the same lines would distribute three and one-half times the number of 220-volt lamps at equal loss. Another advantage on the side of the higher voltage is that the lamps have longer life and about the same maintenance of candle-power. Notwithstanding these obvious advantages, it would seem rather reckless to expend 25 per cent. more energy for a given result in order to avoid the moderate complication incident to two additional inner wires and the necessary balancing apparatus.

Multiples of Eleven and Standard Voltages.

It is surprising to note how generally the many different standard voltages run 10 per cent. higher than a round number. The first standard voltage fixed upon, viz., that of incandescent lamps and two-wire lighting systems, has for years remained at 110 volts, in spite of the efforts of lamp manufacturers to distribute the demand for lamps over a sufficient range of voltage to cover the variations of filament manufacture. The standard voltage of the three-wire system is naturally double that of the two-wire system, or 220 volts, which is now also becoming the standard pressure of high-voltage lamps. The next standard on the ascending scale is that of high-tension three-wire networks, which is 440 volts, there apparently being no call for a standard at or near 300 volts.

Next on the scale is the invariable street-railway standard of 550 volts. This is the upper limit of direct-current standard pressures in this country, giving a wide gap between it and the lowest standard primary alternating pressure of 1100 volts. Double this figure, or 2200 volts, is now becoming the generally accepted standard of alternating-current stations; 3300 is used to a certain extent for suburban extension lines, with house-to-house transformers supplied direct from the line voltage, and 4400 for suburban extension lines with station step-up and step-down transformers feeding 2200 or 1100-volt distribution systems; 6600 volts has been adopted as the line pressure of several polyphase distribution systems supplying rotary-converter sub-stations; 11,000 volts is a standard pressure for long-distance transmission lines. The transformers of such lines are in many cases wound with two high-tension coils which can be connected up for 22,000 volts if desired. Even in cases where pressure higher than this is needed, there may be noted the same tendency to seek a simple multiple of eleven. For instance, a large transmission system in Southern California uses 33,000 volts.

In many cases this remarkable uniformity has been occasioned by the natural tendency to double the previous figure when making a step to a higher standard. In what may be called the original cases, such as 110 and 550, the cause has apparently been a gradual rise from an original round number, settling finally at the ten per cent. increase.

Steam Engine Efficiency.

The experiment recently made at Charlottenburg, Germany, with a view to increasing the working temperature range of an engine is of interest as a purely laboratory demonstration of a scientific truth, but it is highly improbable that steam engine practice will be affected in the least by the experiment. As noted briefly in another column, this experiment consisted of utilizing the heat units of vaporization contained in the exhaust steam of a compound engine to vaporize the sulphur dioxide and using the vapor as the working medium in an auxiliary engine. The vapor exhausted from the cylinder of the auxiliary engine is condensed in the ordinary manner and pumped back to the vaporizer—to be used over again. The exhaust steam from the main engine is condensed in the vaporizer by the liquid dioxide.

This is amazingly beautiful theoretically, and the consular report intensifies the beauty by presenting a superficial array of figures which apparently show a gain of about 50 per cent. in the working heat range. With sciolistic suavity, the report states that the range of a compound-condensing engine is extended from the present practical condenser temperature limit of, say, 140 degrees F., down to 60 degrees F., giving a "clear gain of over 50 per cent." The superficial explanation is put plausibly. Sulphur dioxide does vaporize at a low temperature, and assuming the exhaust temperature of the main engine to be 142 or 143 degrees F., the "boiler" pressure of the dioxide would be about 188 pounds absolute, and if four expansions are obtained the exhaust would be at about 47 pounds absolute pressure, which means 67 degrees F.

The consular report also states that the exhaust from the auxiliary engine is condensed at 60 degrees F. Now, in order to bring the condenser temperature of steam from 140 down to 100 or 105 degrees F., a large quantity of water at low temperature—60 degrees or thereabouts—and a liberal condenser surface are required. It would be interesting to know how much condenser surface and cooling water at available temperatures are re-required to condense the exhaust dioxide at the hypothetical temperature of 67 degrees.

At 140 degrees Fahrenheit, the total heat of sulphur dioxide vapor is 191 B. T. U. per pound, and at 67 degrees the heat of the liquid is 14 B. T. U., so that each pound requires 177 B. T. U. to raise it to 140 degrees and evaporate it. At 183 degrees F. (8 pounds absolute pressure) exhaust steam contains 1138 heat units. Assuming that 1127 are transmitted to the dioxide, 5.8 pounds of the latter per pound of exhaust steam will be required in order that its temperature may be raised to 140 degrees. The latent heat of these 5.8 pounds, when expanded to 67 degrees (47 pounds absolute), will be, roughly, 965 B. T. U., so that about 140 pounds of cooling water, at 60 degrees initial temperature will be required per pound of steam exhausted by the main engine. Moreover, if it is assumed that the condenser range is only 7 degrees, this condition should be applied to the steam engine in order to obtain a reasonable comparison of working temperature ranges. In this case a far different showing would be obtained.

DESIGNS FOR COMBINED ALTERNATING-CURRENT AND DIRECT-CURRENT GENERATORS.—II.

TWO-KILOWATT MACHINE.

BY J. C. BROCKSMITH, M. E.

The 2-kw. machine shown in the accompanying drawings is similar in design, construction and operation to the four-pole machine which appeared in the preceding issue. The present machine is somewhat larger, runs at a slower speed, and has about double the output capacity of the four-pole machine. Fig. 1 gives an end view of the field-magnet frame. There are six poles of laminated iron cast into a circular yoke of cast-iron, which, in turn, is bolted to the base plate by four hexagon cap screws. After the poles are cast in and it is seen that all of them are tight and firm in the yoke, they may be bored out to the proper diameter, 4.04 inches. The armature is to be finished 4 inches in diametr, so that the air-gap will be .02 inch across at each pole; this will be ample for clearance if care is taken in lining up the machine.

Fig. 2 is a section of the assembled machine which shows the construction and relation of the various parts. The armature is of the usual laminated construction, the core discs being held between two cast-iron flanges screwed upon the shaft. If the armature slots are milled out, the discs must be taken apart, cleaned up, and insulated before being finally assembled on the shaft. If this is not done the eddy current loss will be excessive, causing heating and seriously reducing the available output. Fig. 4 shows a detail of the armature shaft. This is intended to be made from 1-inch cold-rolled steel. Threads are cut at both ends of the core portion to receive the cast-iron flanges which clamp the core punchings. Two keys are provided, as shown in the drawing.

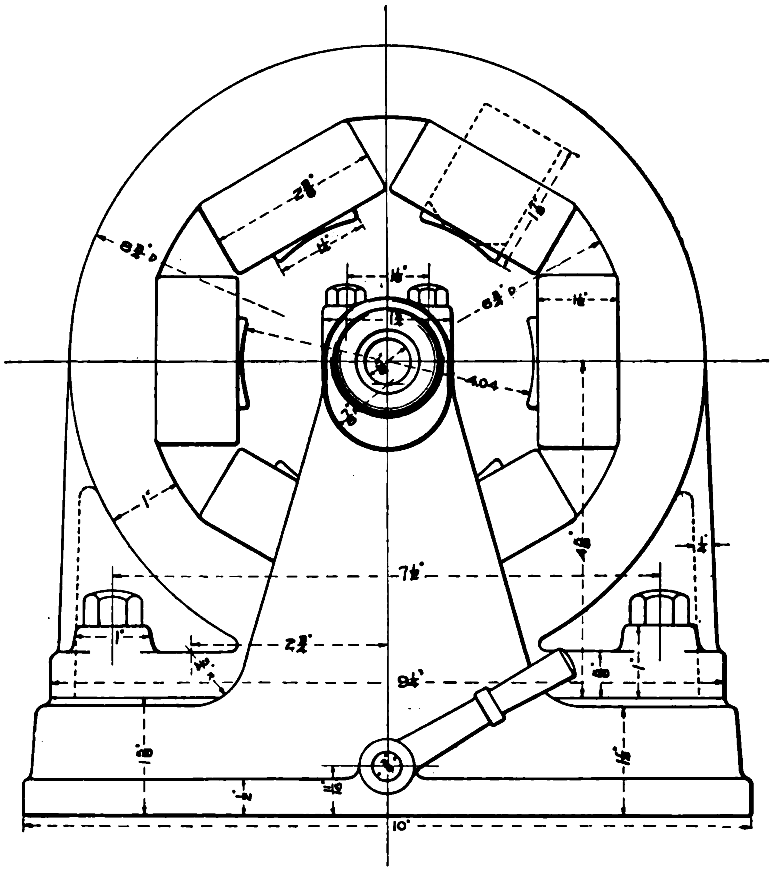

FIG. 1.—END ELEVATION OF FIELD MAGNET.

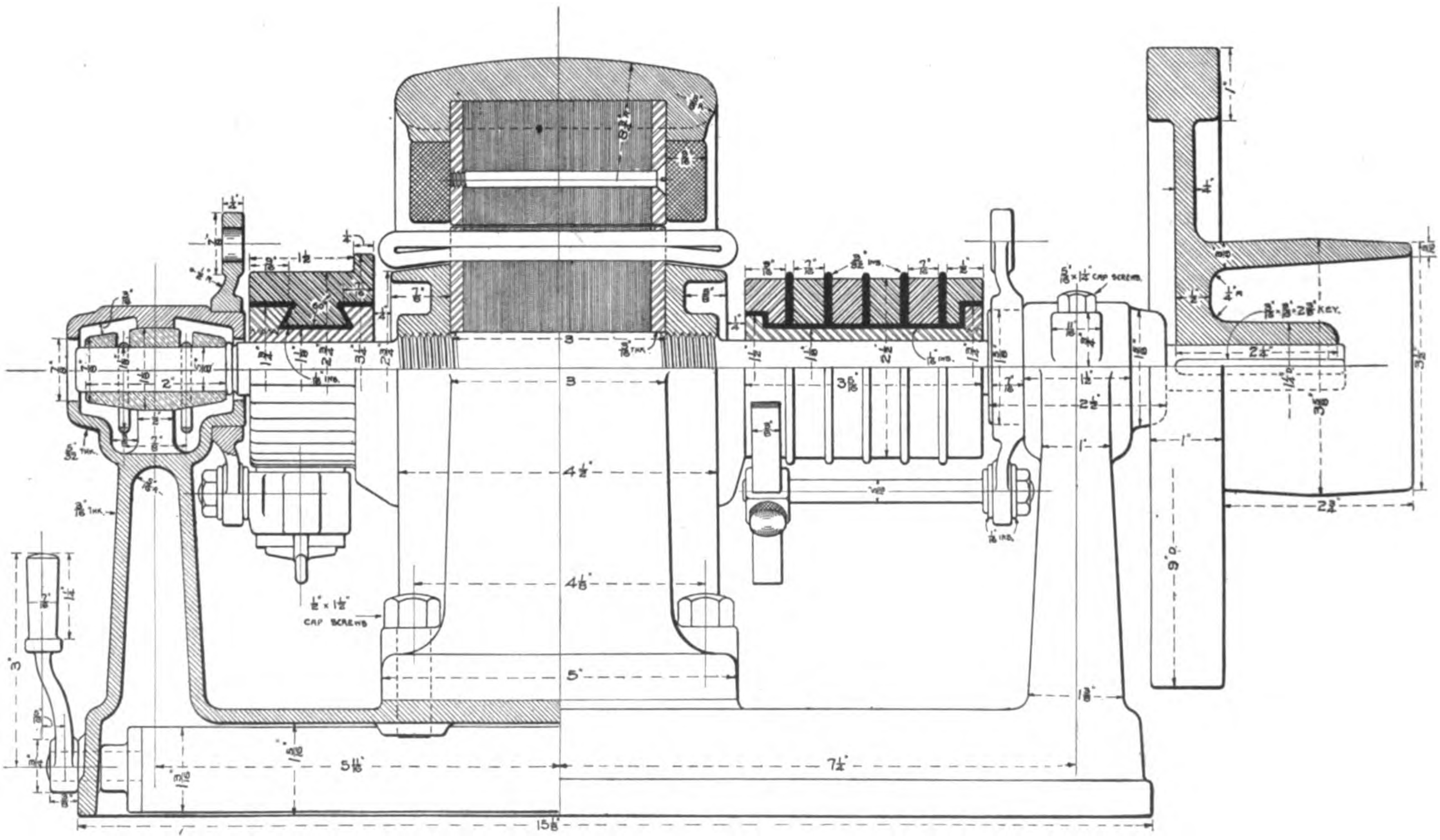

FIG. 2.—LONGITUDINAL ELEVATION OF COMPLETE MACHINE, ONE-HALF IN CROSS-SECTION.

The bearings are made with a brass sleeve fitting the shaft, supported at its center by a projecting web cast in the bracket. Although it is preferable to bore the bracket for this sleeve, the machine work may be avoided by coring the bracket somewhat larger and then babbitting the sleeve into its support when the parts have been lined up in their proper position. The oil rings are of brass ⅛ inch wide and 1⅛ inches inside diameter; grooves are cut eccentrically in the sleeves to receive the rings, the grooves being made about 5/32 inch wide in order to allow the ring a small amount of play.

The commutator is built up on a machine steel sleeve, with the flanges undercut at 60 degrees. The segments may be cast separately or cast as a solid cylinder and afterward cut into segments on a milling machine. The segments should be of copper, with 1/32-inch mica between them, and 1/16-inch micanite, or equivalent insulation, between the sleeve and segments. The number of segments is 36. The collector rings are six in number and mounted upon a sleeve with 3/32-inch fiber discs between the rings. Connections are made by drilling in from the back and soldering in short leads of No. 8 or No. 10 wire, one to each ring. Each of the leads must be carefully insulated from all rings, except the particular one to which it is electrically connected. Some thin copper strips are to be provided with a wrapping of tape and laid in the bottom of the armature slots, six of which must be made 1/16 inch deeper than the rest to accommodate the strips. These strips carry the current across the armature and are connected to the commutator at the proper intervals.

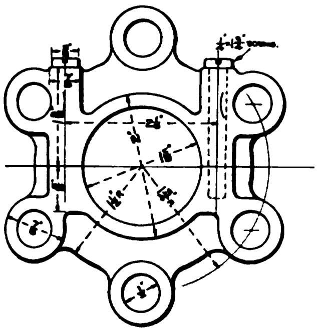
FIG. 5.—BRUSH-HOLDER COLLAR.

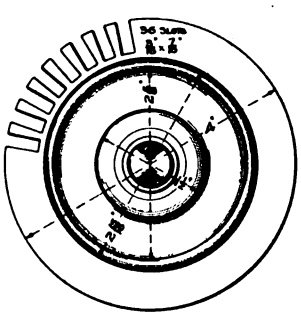
FIG. 6.—END OF ARMATURE CORE.

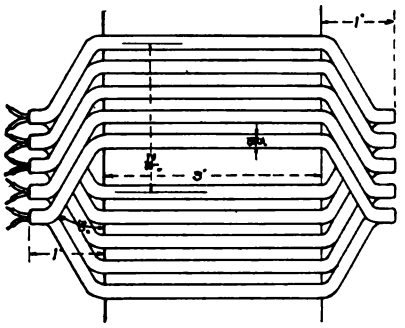
FIG. 7.—DEVELOPMENT OF WINDING.

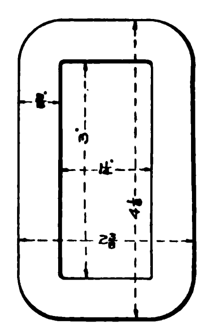
FIG. 8.—FIELD-MAGNET COIL.

At the alternating-current end of the machine the fly-wheel pulley is shown in position on the shaft. This style of pulley will be found advantageous in operating the machine as a rotary converter or in driving it by means of a gas engine. If the machine be used as a motor an ordinary pulley will answer. The pulley is for a 2½-inch belt, and is 3½ inches in diameter.

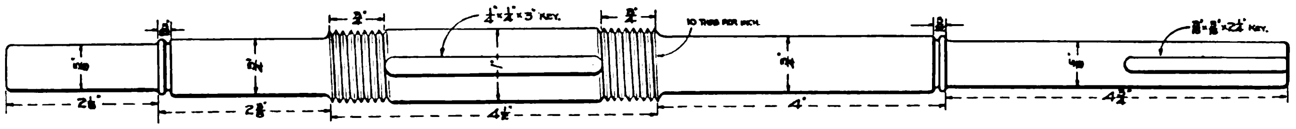
FIG. 4.—ARMATURE SHAFT.

Fig. 5 shows the brush-holder collar. This answers for both the alternating-current and the continuous-current ends of the machine, as there are six collector rings and also six brush holders. Care should be taken in drilling the holes for brush holders to have them equidistant, for upon this the accuracy in spacing the brushes around the commutator depends. At the alternating-current end this does not matter particularly. The brush-holder collars are necessarily made in halves, as it would be difficult to assemble the machine with a one-piece collar.

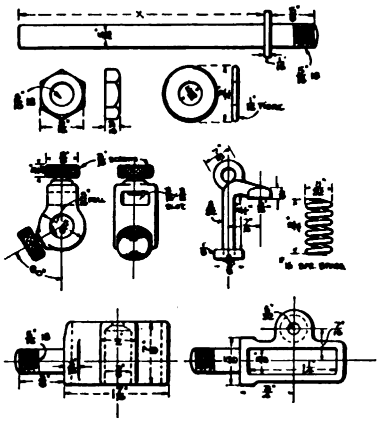
FIG. 3.—DETAILS OF BRUSH HOLDERS.

Fig. 3 shows details of the brush holders. These are of the same type as those already described in connection with the four-pole machine. The alternating-current brush holders have no spring tension and are designed for leaf-copper brushes ⅛ inch thick and ⅝ inch wide. The studs are of different lengths to suit the position of the rings; the dimension, *X*, is 3⅜ inches, 2⅞ inches, 2¼ inches, 1¾ inches, 1 3/16 inches and 11/16 inches for the six studs. They are made of 5/16-inch brass rod. The continuous-current brush holders are designed for radial carbon brushes ⅜ inch thick, 1¼ inches wide and 1⅛ inches long.

Fig. 6 is an end view of the armature core. There are 36 slots, each 3/16 inch wide and 7/16 inch deep; every sixth slot is made ½ inch deep to allow space for the connection strips referred to above. After the coils are in place the armature must be banded at three points, one band to go around the center of the core, and one around each end of the winding where it projects beyond the core. A groove must be turned in the periphery of the core to accommodate the central band, so that the thickness of the band will not be added to the length of the air-gap. This groove may be turned on the core before the slots are milled out, or it may be done afterward by filling in the slots temporarily with hard-wood strips. It should be about 1/16 inch deep and ⅜ or 7/16 inch wide.

Fig. 7 shows a development of the armature winding. This is of the "straight-out" type, and is composed of 36 form-wound coils of No. 20 wire, 16 turns per coil. One side of a coil occupies the top half of slot No. 1, and the other side of the same coil occupies the bottom of slot No. 7; that is to say, each coil spans one-sixth of the circumference of the core. The terminals are brought out at the apex of the coil, and each is connected to the nearest commutator segment; the inside terminal of one coil and the outside terminal of the adjacent coil connect to the same segment. The point of commutation will be found at or near the center line of the pole pieces.

Fig. 8 shows one of the field coils. These are wound on a form, and each coil is divided into two sections of approximately equal resistance, with separate terminals brought out from each section. The size of wire is No. 23, B. & S. gauge.

Fig. 9 shows a diagram of the connections for the collector rings. This arrangement is for a six-pole field. The leads numbered 1 to 6 pass across the armature and are connected to the six collector rings at the alternating-current end of the machine. Connected in this way, single-phase current may be obtained from rings 1 and 2 or 3 and 4, two-phase currents from rings 1 and 2 and 3 and 4, and three-phase currents from rings 1, 5 and 6.

The output and voltage with each of these various methods of working are as follows: Direct current, 15 amperes at 115 volts; single-phase alternating, 15 amperes at 80 volts; two-phase alternating, 11 amperes per phase at 80 volts; three-phase alternating, 9 amperes per phase at 70 volts.

The arrangement employed for starting the machine as a motor on single-phase circuits is as shown in the description of the four-pole machine,* with the single exception that in the present machine there are six coils of two sections each instead of four coils of three sections each.

Fig. 10 shows the arrangement of the switch, cylinder and contacts for the single-phase starting device. There are 30 contact fingers, each 5/16 inch wide, fastened to a strip of fiber ¼ inch thick, which in turn is screwed to the under side of the cast-iron base of the machine. Upon a cylinder of hard wood or fiber 1¼ inches in diameter are arranged two rows of brass pieces, sunk in grooves cut on the cylinder and upon which the stationary contact fingers press.

The cylinder may be rotated through an angle of 120 degrees by means of a handle on the outside. The contacts on the cylinder are 120 degrees apart, which allows sufficient space for the first set to leave contact before the second comes into contact, this being essential to avoid short circuit.

To operate the machine at 110 volts, continuous current, or 125 cycles alternating, the speed should be 2500 r.p.m. For 60 cycles the only method available is to reduce the speed to 1200 r.p.m. and to connect the field winding in series multiple. This is most conveniently done at the starting switch by changing the wiring of the last row of contacts on the switch cylinder, so that when the switch is in the running position the two sections of each field coil will be in multiple and the six multiplied pairs in series and connected across the continuous-current brushes. This will reduce the voltage to about one-half of its value at the higher speed, and the output will then be as follows: Continuous current, 15 amperes at 55 volts; single phase, 15 amperes at 40 volts; two phase, 11 amperes at 40 volts; three phase, 9 amperes at 35 volts. It is probable that by adjusting the field excitation, the voltage could be brought up to 45 or 47 volts, and thus admit of working directly on single-phase circuits of 50 or 52 volts as a motor or rotary without the use of an individual transformer. For other voltages a transformer will be necessary.

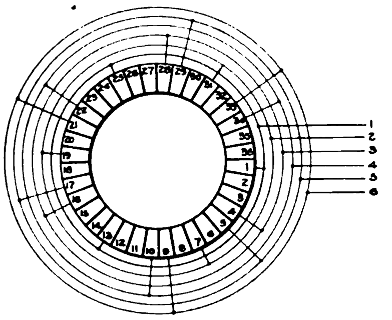

FIG. 9.—DIAGRAM OF TAP CONNECTIONS.

The following is a summary of the data for winding and general dimensions: Speed, 2500 r.p.m. on 125 cycles, or 1200 r.p.m. on 60 cycles. Cast-iron yoke, laminated-iron poles cast in. Armature, 4 inches in diameter, 3 inches long; 36 slots 3/16 inch wide, 7/16 inch deep; every sixth slot ½ inch deep; 36 coils of No. 20 wire; 16 turns per coil, four wires wide and four deep. Total, 1152 conductors. At 15 amperes continuous-current output the cross-section of armature conductors is 400 circ.-mils per ampere.

Useful lines per pole, at 115 volts and 2500 r.p.m.:

$$\frac{115 \times 10_8}{1152 \times 41.6} = 240,000.$$

Total lines per pole, 320,000.

Part.	Total lines.	Cross sect. sq. in.	B.	H.	Length.	Amp. turns.
Armature.	120,000	3.	40,000	10	1.5″	15
2 air gaps.	240,000	4.	60,000	18,800	.04	750
5 teeth	240,000	2.	120,000	180	.44	79
1 yoke.....	160,000	3.5	46,000	102	3.	106
2 cores	320,000	3.75	85,000	18	2.5	45

Total ampere turns in field winding, 995.

Circ. mils field wire (No. 23) =

$$\frac{11 \times 12 \times 500}{16 \times 12} = 345.$$

Mean length per turn, 12 inches. Turns (approx.) per coil, 500; 16 layers of 32 turns each. Resis. of field winding (coils in series), 63 ohms. Normal shunt current, 1 ampere (nearly). Use rheostat of about 40 ohms total in field circuit.

Mean length of wire per armature coil, 16 feet. Total length of armature wire, 36 × 16 = 610 feet. Total weight of armature wire, 2 pounds. Resistance of armature, 0.17 ohm. Drop in armature winding at full load, 2½ volts.

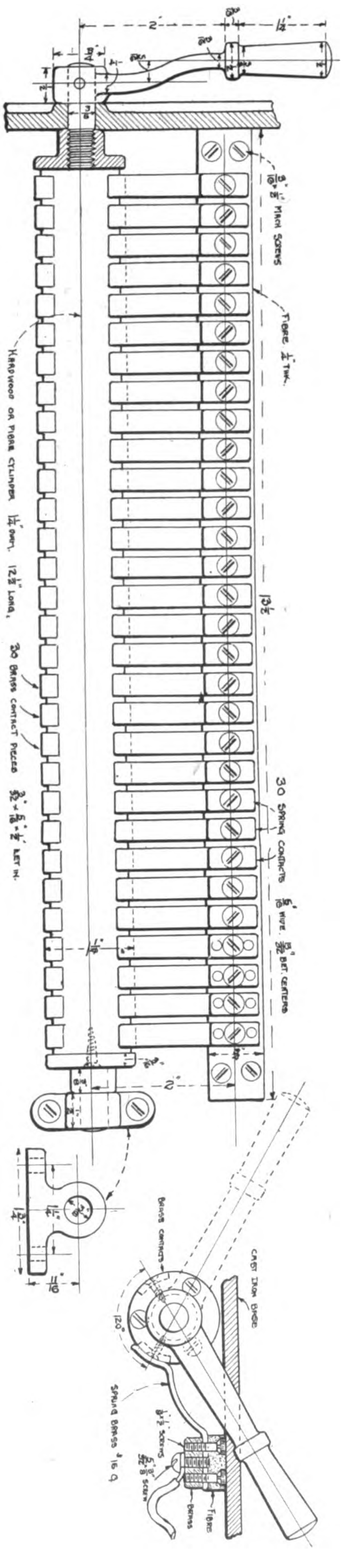
MACH SCREWS
FIBRE ¼" THK.
HARDWOOD OR FIBRE CYLINDER 1¼" DIAM. 12½" LONG,
30 BRASS CONTACT PIECES 3/32" × 5/16" × ¼" LET IN.
13½
30 SPRING CONTACTS 5/16" WIDE. 13/32" BET. CENTERS
2"
BRASS CONTACTS
CAST IRON BASE
120°
SPRING BRASS 16 G
FIBRE
BRASS

FIG. 10.—STARTING SWITCH.

THE ELECTROLYTIC PRODUCTION OF SODA AND CHLORINE.—II.

BY JAMES F. HOBART.

Besides the property of combination mentioned in the previous article, there is another atomic property of each element which must be understood in order to study electro-chemistry, and that is the combining weight, or chemical equivalent is equal to the atomic weight divided by the valency. Thus oxygen has at atomic weight divided by the valency. Thus oxygen has an atomic weight of 15.96, but its valency is 2; therefore the combining weight is 7.98.

Still another point to be covered is the electro-chemical equivalent. Faraday's law as extended by Becquerel, shows that the electric equivalent of an element is proportional to its chemical equivalent, which is equal to its combining weight. In the first part of this article it is stated that the electro-equivalent of hydrogen is .000010384. This means that such a fractional weight of one gramme will be evolved in one second by one ampere of current. The coulomb is one ampere per second, hence the electro-equivalent of hydrogen means that .000010384 gramme of hydrogen will be released or electrolyzed per coulomb of electricity.

By a little calculation we find that it will require 96.302 coulombs to liberate one grain, and it can also be determined that 0.0378 gramme per ampere-hour will be liberated. To apply this to the electrolysis of sodium chloride, we must find the electro-chemical equivalent of sodium, also of chlorine, etc. This may be done by comparing the chemical equivalent of the element with that of hydrogen. For instance, the chemical equivalent of sodium (Na) is 22.99, or that number of times greater than hydrogen, then its electro-chemical equivalent will be 22.99 × .000010384 = .00023873.

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* See Figs. 9 and 10—1 kw. machine; American Electrician for March.

This metal (sodium) will then require 4188.80 coulombs per gramme, and will be deposited at the rate of 0.85942 gramme per ampere-hour. To electrolyze one pound of sodium chloride (453.6 grammes) would require a quantity of current which is determined as follows: Chloride of sodium, as stated above, contains 39.1/74.5 parts of sodium, and 39.1 × 453.6 ÷ 74.5 = 238.07 grammes of sodium, requiring 238.07 × 4188.8 = 997,127.6 coulombs. To do this work in one hour would require a current 997,127.6 ÷ 3600 = 276.9 amperes.

The voltage required is very low, probably not over 1.5 or 2 volts, neglecting resistance of apparatus, which may be considerable. Thus the power required to recover the caustic soda in one pound of salt would be 276.9 amperes × 2 volts = 553.8 watts, or .742 horse-power. If the resistance of the apparatus calls for an increase of pressure to 4 volts, the horse-power absorbed would be 2 × .742 = 1.484, or a little less than 1½ horse-power per pound of salt treated per hour.

A pound of pure caustic soda (NaOH), i. e., 100 per cent., ought to be worth about four cents. It contains Na = 22.99; H = 1 and O = 7.98; then its worth is 22.99 + 1 + 7.98 = 30.97, and 22.99/30.97 parts are sodium. Therefore, from the 238.07 grammes of sodium in one pound of salt there can be made 238.07 ÷ 22.99 × 30.97 = 320.7 grammes, or a little more than three-quarters of a pound of pure caustic soda per pound of salt used, the other elements in the soda, the H, and O, being supplied from electrolysis of the water (HO), in which the elements are dissolved and conveyed to the electrolyzer.

A pound of salt worth 1 cent or less, made into caustic worth 3 cents by the expenditure of three-fourths of a horse-power for one hour is not a good showing when electricity, at the rate of one horse-power per year, ten hours per day, 300 days per year, costs $100, making the cost for current to do the work, 2½ cents per hour. It can, however, be figured another way: 276.9 amperes per hour equals 276.9 ampere-hours. From electric light companies' data it has been found that an average taken from sixty-five plants, the average watt-hours per pound of coal was 91.7, therefore it will require about 3 pounds of coal to electrolyze one pound of salt into about three-quarters of a pound of caustic, and a large quantity of chlorine, as yet undetermined.

There should be no difficulty in obtaining 150, or even 175 watt-hours from a pound of coal, as some of these tests yielded over 200. Taking 150 watt-hours as an average, per pound of coal, the coal required to treat one pound of salt, is 150 ÷ 276.9 = .54 hour per pound of coal, or 1 ÷ .54 = 1.8 pound of coal per hour, per pound of salt.

A certain quantity of chlorine can be obtained from a pound of salt, and, provided that none is lost by being absorbed, there should be obtained from it by electrolysis, 214.5 grammes of chlorine gas which at 3.167 grammes per liter, gives about 68 liters, or 25 cubic feet of gas.

A word of caution may be added regarding the danger of inhaling chlorine gas. It acts upon the membranes lining the throat and nose, causing irritation and inflammation. The effect is much like that of a heavy cold in the head. If this gas is inhaled in concentrated form as it comes from the electrolyzer, it will cause death. It must be diluted with a great deal of air before it can be inhaled without dangerous results. In case chlorine gas is accidentally inhaled, at once pour some alcohol upon a handkerchief or sponge, and inhale the vapor. Ammonia will do as well, or even better, but the vapor of strong ammonia, NH_3, is too harsh to be inhaled, and a bottle containing 1 part ammonia and 5 or 6 parts of water should always be kept handy where chlorine gas is liable to be let loose. The vapor may be inhaled directly from the bottle, or from a cloth or sponge.

If we pass 4 parts of chlorine gas, 4 Cl, into 2 parts of slaked lime, 2 $Ca(OH)_2$, the result will be 1 part of bleaching powder, $Ca(ClO)_2 + CaCl$, and 2 parts water, 2 H_2O. In order to ascertain how much bleach can be made from 68 liters of electrically-liberated chlorine, we must first find the weight of each element in the compound. The reaction is as follows:

$$2\ Ca(OH)_2 + 4\ Cl = Ca(ClO)_2 + CaCl_2 + 2\ H_2O.$$

From the quantities of the elements, and their combining atomic weights, the following table is deduced:

Element.	Combining weight.	Number of parts.	Total weight.	Per cent. of each.
Ca	39.91	2	79.82	27.6062
O	15.96	4	63.84	22.0892
H	1.	4	4.	1.3834
Cl	35.37	4	141.48	48.9312
Total			289.14	100.

This demonstration shows that nearly 50 per cent. of the total amount must be chlorine, which is to be added to the lime. From the 1 pound of salt electrolyzed there were obtained, as stated above, 214.5 grammes of chlorine (Cl), which, entering as 48.9312 per cent., would convert 214.5 ÷ 48.931 × 100 = 438.8 grammes of slaked lime, CaO_2H_2, into chloride of lime or bleaching powder. This is pretty close to 4 parts of lime to 2 of chlorine, as stated above, but a certain quantity of water is formed during the union of the lime and chlorine.

The hydrogen and oxygen combine to form water, which forms 13.964 per cent. of the whole weight after combination. There were 438.3 grammes of lime and 214.5 grammes of chlorine, giving 652.8 grammes of bleaching powder; removing 13.9 per cent. of this by evaporation, to get rid of the water, and there are left 562 grammes of dry chloride of lime, just about 1.23 pounds, or a pound and a quarter.

To ascertain the amount of water thus formed, the following table has been prepared, which gives the elements as they occur in the formula after the reaction, viz.:

Element.	Combining weight.	Number of parts.	Total weight.	Per cent. of each.
Ca	39.91	1	39.91	13.8031
Cl	35.37	2	70.74	24.4656
C	15.96	2	31.92	11.0396
Ca	39.91	1	39.91	13.8030
Cl	35.37	2	70.74	24.4656
H	1.	4	4.	1.3834
O	15.96	2	31.92	11.0396
Total			289.14	100.

The value, then, of a pound of salt after electrolysis is as follows:

	Cents.
Three-fourths pound pure caustic soda..	3
One and three-fourths pounds chloride of lime	3
Total	6

To secure this result there has been consumed:

	Cents.
One pound of salt	1
About one pound of lime	0.4
1.8 pounds of coal	0.36
Total	1.76
Balance	4.24

From which are to be deducted the cost of labor, interest on plant, etc. There seems to be quite a margin in the electrolysis of salt, especially for paper-making purposes.

In calculating the quantity of caustic soda formed from a pound of coal, it was shown that the soda contained 238.07 grammes of sodium. The other elements (H and O), to the amount of 89.64 grammes, were drawn from the electrolysis of water in which the sodium chloride was dissolved. There is also a quantity of hydrogen liberated at the cathode with the soda which may help to form the caustic soda.

Indeed, it seems from the reaction which takes place here, as if, by the introduction of a little extra oxygen, the escaping hydrogen might be all combined into caustic soda, and quite a saving made thereby, as well as increasing the electrical efficiency by preventing polarization, which is due to the gathering of bubbles of hydrogen on the cathode. The reaction indicated is as follows: $Na + H_2O = NaHO + H$.

Now by adding another atom of oxygen, twice the quantity of sodium can be combined, and twice the amount of caustic formed, besides getting rid of the hydrogen as stated, thus: $2\ Na + H_2O + O = 2\ NaHO$.

Here is a "pointer" for the electrolysis man to work upon.

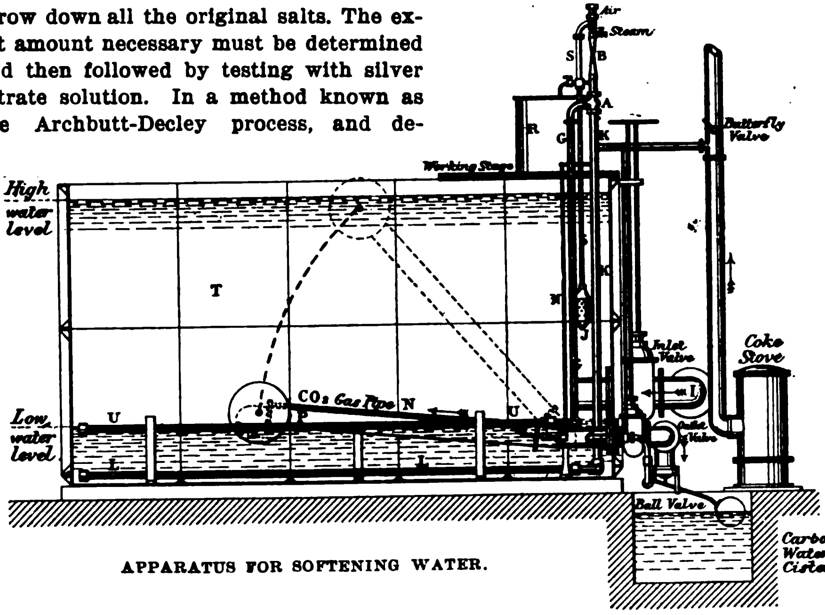
◆

Electrical Equipment for the New Mint.—The plans for the new Philadelphia mint call for a considerable equipment of electrical apparatus, which includes 14 motors of 45 h.p. each, for the coining department, 16 cutting motors of 5 h.p. each, and six finishing motors of 25 h.p. each. An electro-metallurgical equipment is also to be installed for the melting and refining department of the mint.

FEEDWATER PURIFICATION.—II.

EXTERNAL METHODS.

One of the oldest methods of purifying water when carbonate of lime is the salt contained, is by the addition of more lime in the shape of the hydrate (slaked lime); water containing this salt is sometimes called "chalk water." If all the carbonic acid be driven out by boiling, the lime will be precipitated. It is also possible, as stated above, to add more lime and thereby precipitate the whole amount contained in the water. It is about 100 years since this method, which was patented in 1841, was first advocated. It is, however, necessary to add exactly the proper amount of lime, as more or less will not throw down all the original salts. The exact amount necessary must be determined and then followed by testing with silver nitrate solution. In a method known as the Archbutt-Decley process, and described by the author of that process at a meeting of the British Institution of Mechanical Engineers, it was stated that quicklime and anhydrous carbonate of soda (58 per cent. alkali) were employed. After the required amount had been weighed out, the lime was slacked in a small tank, then blown by steam pressure into another vessel, where the alkali was added, and the whole boiled until the alkali was completely dissolved.



APPARATUS FOR SOFTENING WATER.

The quantity of reagent solution thus prepared was put in the precipitating tank with the stated amount of water, and by means of an air jet thoroughly mixed therewith; then, after an hour's settling, the clear water was drawn off. It has been found necessary to complete the operation by carbonating the water, and that is effected by means of a floating discharge appliance which takes the water from the surface of the settling tank. Gas from a coke stove supplies the necessary carbonic acid gas for impregnating the water, and the carbonating is effected by the meeting of the gas and water in the apparatus above mentioned. This carbonating is for the purpose of changing any residual lime which might remain in the water from carbonate to bicarbonate. The bicarbonate is soluble, and does no damage, while the residual carbonate, under the influence of heat, is thrown down in the inspirator, thereby coating—when subjected to steam heat—the working surfaces of that apparatus with scales and rendering it useless.

Precipitation is much advanced by the peculiar action of the air blast above noted. The air turned into the tank passes downward and stirs up some of the sediment left in the bottom of the tank from previous operations. The coarse precipitate thus stirred up settles very easily and quickly, and takes with it much of the very fine precipitate formed from the charge of water then in the tank, thereby shortening the settling process very materially; it is often reduced by this means to 60 minutes, as indicated in the preceding paragraph.

The accompanying engraving enables the described operations to be readily traced. The blower for supplying the current of air is shown at the top of the engraving, both the steam and the air pipes being indicated. To test the water, a small quantity is poured into a small white basin containing a few drops of silver nitrate solution. If the right quantity of lime has been added the resulting color will be a pale yellow. If too little lime has been used, a milky whiteness will be produced. Too much lime will cause the resulting color to be more or less dark brown. The following table shows the approximate cost of chemicals for treating water of various kinds. A few of these plants are in operation in America, where the matter of feed-water purification has not received as much attention as it is entitled to, or as it receives in England or on the European continent.

TABLE SHOWING THE VARIABLE CHARACTER OF WATER FROM DIFFERENT SOURCES AND THE CONSEQUENT DIFFERENCE IN THE COST OF SOFTENING.

Source	Well.	River.	River.	River.	Canal.	Well.	Brook	Well.	Dis-used shaft	Clay pit.
	Grains per gallon.									
Calcium carbonate (Carbonate of lime)	10.00	8.74	13.15	16.39	10.99	9.19	2.06	9.41	8.34	1.39
Magnesium carbonate	4.76	2.78	.33	.31	2.76	1.40	.94	1.00	3.82	1.78
Sodium carbonate	4.19	.....	......	....	..	......	.....			......
Calcium sulphate (Sulphate of lime)	......	3.26	.....	4 30	2.99	12.17	47.34	22.91	40.60	54.14
Magnesium sulphate	....	....	1.96	1.28	12.41	7.05	5.70	15.90	22.25	22.46
Sodium sulphate	4.15	1.44	.30	......	18.96	......	9.98		2.65	28.96
Magnesium nitrate	......	.....	....	......	......	13.69	......	11.50		......
Sodium nitrate	......	......	.96	small	. .	......	......	......	small	......
Magnesium chloride	......	......	......	......	......	.61	.....	2.08	......	......
Sodium chloride	1.65	2.72	2.06	3.05	5.28	6.30	6.70	5.05	6.35	5.28
Silica	.....	.43	.39	.42	.51	.62	.62	.90	.84	.36
	24.75	19.37	19.15	25.75	53.70	51.06	73.41	68.75	83 36	114.37
Total lime (Ca O)	5.60	6.24	7.36	10.95	7.39	10.16	20.64	14.70	21.39	23.07
Total magnesia (Mg O)	2.28	1.33	.81	.58	5.48	7.02	2.36	9.82	8.81	8.38
Calculated hardness (i. e., total lime and magnesia, calculated to carbonate of lime)	15.65	14.5	15 15	20.99	26 77	35.53	42.7	50.57	60.02	61.95
Approximate cost of chemicals required for softening 1,000 gallons	0.4c.	1.0c.	0.8c.	1.2c.	2.4c.	4.0c	5.6c.	6.2c.	7.2c.	8.4c.

NOTE.—The above estimates of cost are based upon quicklime at $5 per ton and 58 per cent. alkali at $20 per ton.

This method of purifying feed water is the property of Mather & Platt, Limited, Manchester, England. A process somewhat similar, but without the apparatus shown in the engraving, has been recently described by Mr. A. B. Cary, an American engineer. In this process it was shown that the water to be treated could be put into a tank fitted with paddle wheels or other stirring apparatus and the necessary amount of lime water admitted to throw down the carbonate of lime contained in the water in the tank. After this had been done, a solution of soda was run into the tank, and the stirring again commenced to mix the second solution thoroughly with the contents of the tank. After the second stirring the water was allowed to stand as long as possible, according to the capacity of the tank and the demands of the boiler. More time was allowed than in the first method described, from five to seven hours being desirable when possible. The addition of soda is for the purpose of taking care of the sulphate of lime, and it is figured that by the treatment the sulphate of lime is changed into the mono-carbonate of lime.

The above mentioned precipitate being insoluble, it cannot be dissolved by the water, and if not carried along mechanically in the same manner that sand is transported, it will be deposited in the bottom of the settling tank. The other resulting product of the chemical transformation will be sulphate of soda, which will remain in solution in the boiler at all ordinary temperatures, so that if the boiler is blown off occasionally, a portion of the water being released every few hours, the sulphate of lime will be removed by such action without doing damage to boiler by being deposited as scale.

The amount of lime and soda necessary in any case must be determined from a chemical analysis of the water to be treated. Once having determined the quantity of carbonate and sulphate of lime in a given sample of water, it is merely a matter of simple arithmetical calculation to determine how many pounds or ounces of each substance there is in a certain quantity of water. Then it only requires another simple calculation to determine the amounts of the reagents that will combine with the stated amount of lime in a given quantity of water. Usually the amount of reagent necessary will be modified slightly by experience, but the calculations above indicated are correct for commencing operations.

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ONE-MINUTE TELEPHONE RATES.

BY E. D. TROWBRIDGE.*

Some time ago the management of the Michigan Telephone Company decided on a new schedule of time rates based on minute conversations, the idea being to place the telephone within the reach of customers who wished to transmit short messages. It was figured that from 150 to 200 words could be easily transmitted by telephone within one minute, and a schedule was adopted making the rate one-fifth of the old standard five-minute rates, with a minimum charge of 15 cents for minute service. In other words, the rate between two points 100 miles distant from each other, would, under the new schedule, be 20 cents for one minute, with a charge of 20 cents for each additional minute. The rate for a distance of 35 miles would be 15 cents for one minute, with a charge of 5 cents for each additional minute. The new rates have been applied by the company on certain routes as fast as the construction of additional facilities enabled the company to take charge of an increase in the business, and have proved popular, bringing a very large increase of business wherever they have been applied.

The time rates charged by most telephone companies were formerly based on five-minute conversations, and in case of messages passing over a long stretch of wire, the five-minute rates were so high as to prevent a popular use of the service. A large majority of the telephone companies now operate on a three-minute schedule, and the experience of each company has been that the change to a three-minute basis has greatly increased the volume of business and the earnings of the various companies. The writer believed that by adopting a minute schedule considerable new business would be induced and the service would be made more popular by charging only for the actual time consumed in the use of the line; the experiment has vindicated the belief.

After a careful study of the matter, the writer is convinced that the average conversation can be kept within one minute and a half. The trouble in the past has been that as the time limit was long, subscribers strung out their conversations and introduced into such conversations a great deal of superfluous matter which they never would have thought of putting in a letter or telegram. I find that as subscribers become accustomed to the new rates they talk business only, and put their conversations through in less time and in much better shape. There is a tendency to so increase the volume of business between given stations as to warrant direct circuits and, consequently, to build up a large business which can be handled much more economically than where a number of messages are scattered over large territory.

One-minute rates have been such a success in Michigan that the same schedule will be introduced as rapidly as possible on the lines of the Wisconsin Telephone Company and the Northwestern Telephone Exchange Company, both of which are controlled by the Erie System. It is hoped, within a year, to have minute rates throughout Michigan, Wisconsin, North Dakota and South Dakota.

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*General Superintendent, Long Distance Service, Erie Telephone System.

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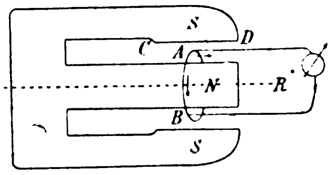
Letters on Practical Subjects

Difference of Potential and E. M. F.

To the Editors of American Electrician:

Sirs:—In the February number of the American Electrician the article on "Difference of Potential and Electromotive Force" makes the distinction quite clear theoretically, but can it be proved experimentally that a current is flowing in the coil shown in the illustration? If the ring is cut and an instrument inserted then a difference of potential exists. The current cannot be indicated by a magnetic needle as the needle would have to be inserted in the field between the poles N and S. The only apparent way to measure the current seems to be to determine the work done in moving the ring through the field, and this would be almost as difficult to accomplish experimentally as to measure the current direct, as the forces would be small. It would be quite interesting if proof of the difference between potential difference and e. m. f. could be determined experimentally.



A CASE OF ELECTROMOTIVE FORCE WITHOUT DIFFERENCE OF POTENTIAL.

J. Rowland Brown.

Mansfield, Ohio.

[The matter scarcely requires experimental proof in the light of the fundamental principles of electro-magnetic induction, which were long ago established both mathematically and experimentally. The ring cuts lines of force if moved parallel with its core; or, if the "threading" hypothesis be preferred, the number of lines of force encircled by the ring will be changed by any movement of the ring. Hence, an e. m. f. will be induced in the ring.—Eds.]

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The Effect of Joint Resistance on Railway Electrolysis.

To the Editors of American Electrician:

Sirs:—I note in your March issue an article by Mr. A. A. Knudson regarding the effect of joint resistance on railway electrolysis. Mr. Knudson put forth clearly the well-known fact that the resistance at pipe joints in underground piping increases with age, and the cause of this increase is undoubtedly, as he states, local electrolytic action or erosion between the lead and iron in the ball and spigot joint. I have noticed for a number of years that currents did fall off in pipe returns with time, even when the bonding of paralleling roads depreciated in conductivity; and this very feature is one by which we account for the effects of electrolysis on underground piping, noted in the early roads, which were so much criticised when the trolley rail-return system was instituted, and because of which the early failure of water pipe system were predicted. This was ten years ago and we hear less of it now on account, to some extent, of the very protection caused by the increased resistance of these joints which reduces the current flow possible through the pipes. The joints in the water piping recur every 10 feet, and this, in time, produces instead of a low resistance conducting system, a high-resistance return conductor, and in this way dams the current flow in the water pipes and protects them from further damage.

It must be remembered that in order for the current to pass around through the spigot joint into the earth surrounding the pipe or through the water inside of the pipe a considerable difference of potential must exist. I have not found any action to take place under 0.6 volt potential difference, and there being 520 joints per mile of rail, 316 volts per mile are required in order to do any damage. Of course, with this difference of potential at the rail, assuming that the pipe and rail are metallically connected at the end of the mile in question, the road would be inoperative, but it must be also considered that the earth resistance between the rail and the pipe will add resistance to the pipe return circuit unless the water companies have placed their gate boxes against the rail or established other metallic connections from the rails to the pipe system. This has happened in a number of cases I have investigated, but the rare cases in which pipe joints have suffered have been few and far between; nevertheless this local difficulty has been assigned to the whole pipe system, and consequently a great deal has been made out of a small trouble. It is very easy to locate these bad joints electrically where there is any flow of current in the water pipe system, and to take care of them by bridging or a proper ground return.

Without going into the general question of how to protect pipes from electrolysis, I will take up Mr. Knudson's question of Albany. Mr. Farnham did find corrosion at the joints of pipes in Albany some six years ago. Ground returns were connected to the water pipes and taken back to the station and the water superintendent testified in an affidavit last November that he had experienced absolutely no difficulty from electrolysis since these connections had been made at Albany.

There are so many places where returns have been placed to lead, or "drain," so to speak, the electrical current off from the water pipe system back to the station in such a manner as not to produce any difficulty from electrolysis to the water pipe system where due care has been taken by the water companies to protect themselves, that the system of electrical "drainage" is now nearly universally accepted as the solution of this trouble.

The experience with the double trolley roads, of which there have been some 25 in the United States from 1892 to 1899 (a not very encouraging example still surviving at Cincinnati) has not been sufficiently satisfactory to encourage engineers to advise the double overhead trolley construction on any roads. As in Cincinnati, certain cars can be operated without the negative trolley being in contact with its trolley wire, and as there is no bonding on the rails at all, we may expect the very trouble which this double trolley system is supposed to obviate.

It seems as reasonable for the water company to ask the railway company to take its ground return off the rails and put it in the air as for the railway company to ask the water company to erect its water pipe system over the house tops, while there is a perfectly reasonable and simple method of obviating the difficulty complained of. This is not mere abstract theory but a statement based on knowledge gained from an extensive practice. What is really needed to obviate or cure electrolysis troubles is intelligent co-operation between the water and railway companies in order that both may peacefully occupy the earth together without detriment to the earth.

Albert B. Herrick.

New York, March 12, 1900.

To the Editors of American Electrician:

Sirs:—Mr. Knudson's article in your March issue on the effect of pipe joints upon electrolysis due to railway currents was extremely interesting and his arguments incontrovertible upon the basis assumed—bonded track return. Without intending any discourtesy to Mr. Knudson or criticism of his known high ability, I am constrained to point out the fact that his exhaustive discussion of the facts considered is unnecessary because the conditions under which those facts need to be taken into consideration are absurd and cannot endure.

There is not much more sense in using the track as the sole return conductor for a railway system than there would be in utilizing the gas pipes of a residence as one leg of an incandescent lamp circuit. When railway companies refrain from niggardly skimping and install rational two-wire systems of feeders, as they will be compelled to do in time, the electrolysis ghost will be laid.

Geo. W. Malcolm.

Brooklyn, N. Y., March 15, 1900.

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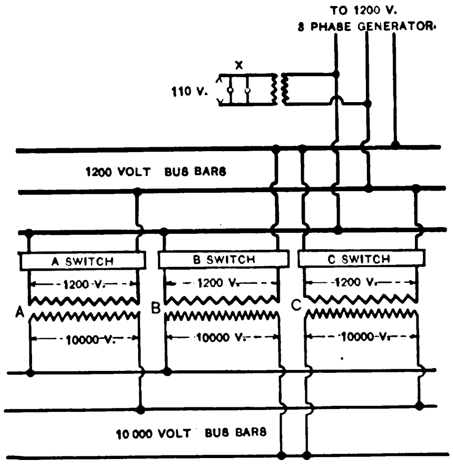
A Polyphase Puzzle.

To the Editors of American Electrician:

Sirs:—Referring to the puzzle which appeared in your issue of November, 1899, I think that either the fuse of the middle wire or that of the left-hand wire of the 1,200-volt generator could have blown. If the fuse in the middle wire had blown, closing the switch B would give no light at X, and with B and C closed full light would be obtained. With all three switches closed half candle-power would be obtained. Also if the fuse in the left-hand leg had blown, closing the switch at C would give no light at X, while closing B and C would give full light at X and with all three switches closed half candle-power would be obtained at X.



A POLYPHASE PUZZLE.

E. H. Steel.

Little Shasta, Cal.

Lessons in Practical Electricity

TRANSFORMERS.

If a current be passed through a coil of wire encircling a bar of soft iron the iron will become a magnet; when the current is discontinued the bar loses its magnetization. Conversely, if a bar of iron carrying a coil of wire be magnetized in a direction at right angles to the plane of the coil a momentary e. m. f. will be induced in the wire; if the current be reversed, another momentary e. m. f. will be induced in the opposite direction in the coil. These actions have been fully explained in the more elementary lessons previously published, and as they are a perfectly familiar phenomena a detailed explanation of the principles upon which they depend is not necessary here.

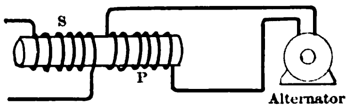


FIG. 1.--ELEMENTARY TRANSFORMER.

From the first two statements given above it is evident that if a bar of iron be provided with two coils of wire, one of which is supplied from a source of alternating current, as shown diagrammatically by Fig. 1, at each impulse of the exciting current an e. m. f. will be induced in the other coil, S, the direction of these impulses alternating like that of the exciting current. In such a case, the flux emanating from the north pole of the bar has to return to the south pole through the surrounding air; and as the reluctance of air is much greater than that of iron, the magnetism will be much weaker than if a continuous core were used, as in Fig. 2. Such an arrangement constitutes an elementary transformer.

If the windings were put on as indicated in Fig. 2, the leakage of magnetic lines of force would be excessive, as indicated by the dotted lines in Fig. 3. In such a case the lines which leak through air have no effect upon the secondary winding, and are therefore absolutely wasted. In commercial transformers, and even in ordinary induction coils (the operating principle of which is the same as that of transformers) the magnetic leakage is reduced to the lowest possible amount by arranging the coils one within the other, as represented in Fig. 4, where C is a cross-section of the iron core; P is the primary coil, and S is the secondary. This arrangement compels practically all of the magnetic lines created by

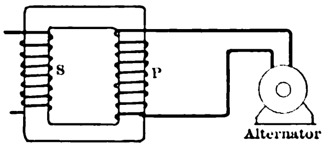


FIG. 2.--ELEMENTARY TRANSFORMER, CONTINUOUS CORE.

the primary winding to pass through the secondary winding.

The magnetic flux increases, decreases and reverses with the rise, fall and reversal of the current in the exciting coil, P, which for ordinary purposs of calculation is assumed to follow the sine law. That is to say, if it were possible to construct an ammeter so sensitive that its needle would follow the variations in the current strength accurately, a siphon pen mounted on the end of the ammeter needle and arranged to trace a curve on a sheet of paper continuously moved in a direction perpendicular to the average direction of motion of the ammeter needle, a sine curve would be drawn, as shown by Fig. 5. That part of the curve lying above the zero or datum line indicates the variation in current strength in a positive direction and the corresponding variation of magnetic lines; that part of the curve lying below the datum line similarly shows the variations of the current strength and number of lines in the opposite direction. As explained in previous lessons, the one complete reversal of current represented by the curve shown is known as a "cycle," or "period."

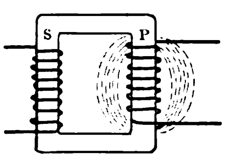


FIG 3.—MAGNETIC LEAKAGE.

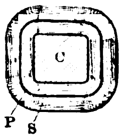


FIG. 4.—SUPERPOSED COILS.

In order that the iron may respond more readily to the magnetizing currents, which will receive attention later, the core of a transformer is divided up into very thin sheets or plates instead of being made solid like the core of an ordinary electromagnet. Even this precaution does not entirely eliminate the troubles referred to. The iron of the core may be considered as resisting the efforts of the exciting current, this resistance causing a sluggishness in both the rise and fall of the magnetic strength as compared with the variations in the exciting current strength. This effect is known as "hysteresis"; the smaller the cross-section of each individual piece of iron in the core (the total core cross-section being unchanged) the less will be the hysteretic effect.

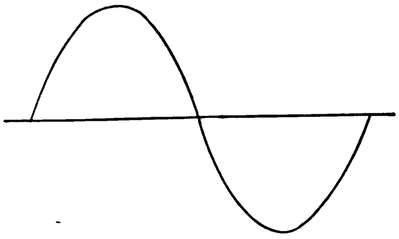


FIG. 5.—SINE CURVE.

This opposition to the influence of the exciting current is a molecular phenomenon and must not be confused with the magnetic "reluctance" of the core, which corresponds with the electrical resistance offered by a conductor to the passage of a current. Hysteresis is more nearly analagous to the inertia of physical bodies which causes them to resist any change in their rate of motion, or change from a motionless to a moving state. Reluctance and electrical resistance correspond roughly to the friction between water and the walls of a tube through which it flows. The reluctance of an iron or steel core increases with the increase in the magnetic density—i.e., the number of magnetic lines of force passing through each unit of cross-sectional area; the hysteresis also increases with the magnetic density, as will be explained further along.

As the magnetic flux increases and decreases in strength and reverses in direction, the e. m. f. induced by it in the secondary winding rises, falls and reverses, not synchronously with the variations in the flux, but a quarter of a cycle or period later. The reason for this is that the value of any induced e. m. f. depends upon the rate of change in the number of magnetic lines which induce it, not merely upon the number of lines. Reference to Fig. 6 will show that the number of lines of flux changes most rapidly when the direction of the flux reverses; this point in the diagram is where the curve representing the magnetic flux crosses the zero or datum line. Consequently, at this moment the induced e. m. f. will be at its maximum point, as indicated in the diagram.

It is evident that if the variations of flux in the core induce a variable e. m. f. in the secondary winding they will have the same effect, simultaneously, upon the primary winding; they cannot affect one wire and skip the other one. This results in a "back" or counter e. m. f. in the primary winding which opposes the impressed e. m. f. of the line from which the exciting or primary current is supplied. The back e. m. f., however, does not rise and fall exactly in opposition to the impressed e. m. f., but a little behind it, as to time. The various actions in the primary winding can be best considered by ignoring the secondary winding; for the present, therefore, we will imagine that there is no secondary winding at all. Then the relations in the primary winding are as follows:

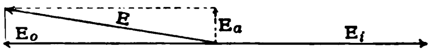


FIG. 8.—VECTOR DIAGRAM OF PRIMARY ELECTROMOTIVE FORCES.

The primary current and the magnetic flux in the core rise and fall practically in unison so that a single curve will be sufficient to represent the variations of both the magnetic flux and the primary current, as in Fig. 6. The induced or "back" e. m. f. in the primary winding does not rise and fall in unison with the primary current and the magnetic flux, but lags behind them ¼ of a cycle, as indicated in Fig. 7. (For convenience in calculation an alternating-current cycle is divided into degrees corresponding with those of a circle, a complete cycle being assumed to contain 360 degrees, hence the induced e. m. f. is said to lag behind the exciting current 90 degrees.)

It is obvious that an e. m. f. which varies in unison with the exciting current must be supplied in order to force this current through the winding. This e. m. f., which is usually referred to as the active e. m. f., is represented by the flatter curve on the diagram, and its value is found by Ohm's law; thus the exciting current multiplied by the resistance of the winding equals the active e. m. f. It is also evident that the induced e. m. f. must be opposed by an equal e. m. f. in phase with it; this e. m. f. forms the other component of the impressed e. m. f.

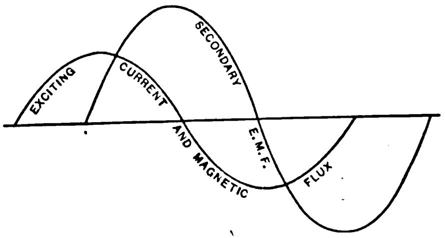


FIG. 6.—LAG OF INDUCED E. M. F.

A clearer idea of this combination may be had by considering each e. m. f. as a mechanical force, the phases corresponding to directions of the mechanical forces. For example, in Fig. 8, let Ea represent the active e. m. f. spent in overcoming the resistance of the winding and Ei the induced e. m. f. Then Eo will represent the e. m. f. that balances Ei, preventing it from doing any work, and as Eo and Ea are components of the impressed e. m. f., the latter is obtained by combining the two smaller forces according to the law of the parallelogram of forces, giving the line, E. If the lines, Ea, Ei and Eo be drawn to scale so that their lengths are proportional to the respective voltages, then the length of E will represent, to the same scale, the impressed volts of e. m. f, and the angles between the lines will indicate the phase differences in electrical degrees (360ths of a cycle). In actual practice the active e. m. f. is even smaller in comparison with the others than indicated by the diagram. Here its comparative length is exaggerated in order to more clearly illustrate the "angular" relationship.

It will be noticed that the back or counter e. m. f., Ei, is very nearly as great as the impressed e. m. f., E, and almost squarely opposed to it. This explains the fact that a primary winding having a resistance of only a few ohms will pass only a very small current when 1000 volts are applied to the primary terminals, with the secondary circuit unclosed. Most of the 1000 volts is opposed by the counter e. m. f. of induction, as clearly indicated by the diagram.

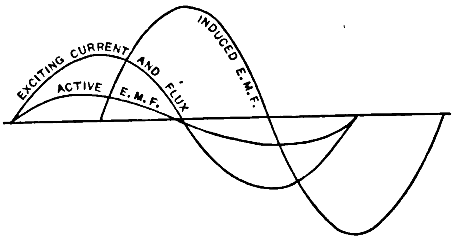


FIG. 7.—PRIMARY PHASE RELATIONS.

Electrical Catechism

434. What is meant by the international electrical units?

These are units recommended by the International Congress of Electricians held in Chicago during the World's Fair of 1893 and later adopted by various governments, the United States Congress approving and adopting them in June, 1894. These units include the ohm, ampere, volt, coulomb, farad, joule, watt and henry.

35. What is the international ohm?

"The unit of resistance shall be what is known as the international ohm, which is substantially equal to one thousand million units of resistance of the centimeter-gram-second system of electromagnetic units, and is represented by the resistance offered to an unvarying electric current by a column of mercury at the temperature of melting ice fourteen and four thousand five hundred and twenty-one ten-thousandths grams in mass, of a constant cross-sectional area, and of the length of one hundred and six and three tenths centimeters." This unit is named after George Simon Ohm, a German electrician who lived from 1789 to 1854.

436. What is the international ampere?

"The unit of current shall be what is known as the international ampere, which is one-tenth of the unit of current of the centimeter-gram-second system of electromagnetic units, and is the practical equivalent of the unvarying current, which, when passed through a solution of nitrate of silver in water in accordance with standard specifications, deposits silver at the rate of one thousand one hundred and eighteen millionths of a gram per second." This unit is named after Andrè Marie Ampere, a French physicist who lived from 1775 to 1836.

437. What is the international volt?

"The unit of electromotive force shall be what is known as the international volt, which is the electromotive force that, steadily applied to a conductor whose resistance is one international ohm, will produce a current of an international ampere, and is practically equivalent to one thousand fourteen hundred and thirty-fourths of the electromotive force between the poles or electrodes of the voltaic cell known as Clark's cell, at a temperature of fifteen degrees Centigrade, and prepared in the manner described in the standard specifications." The volt is named after Alessandro Volta, an Italian physicist who lived from 1745 to 1827.

438. What is the international coulomb?

"The unit of quantity shall be what is known as the international coulomb, which is the quantity of electricity transferred by a current of one international ampere in one second." This unit is named after Charles A. Coulomb, a celebrated physicist who lived from 1736 to 1806.

439. What is the international farad?

"The unit of capacity shall be what is known as the international farad, which is the capacity of a condenser charged to a potential of one international volt by one international coulomb of electricity." This unit is named after Michael Faraday, a celebrated English physicist who lived from 1791 to 1867.

440. What is the international joule?

"The unit of work shall be the joule, which is equal to ten million units of work in the centimeter-gram-second system, and which is practically equivalent to the energy expended in one second by one international ampere in an international ohm." (See No. 422.)

441. What is the international watt?

"The unit of power shall be the watt, which is equal to ten million units of power in the centimeter-gram-second system, and which is practically equivalent to the work done at the rate of one joule per second." (See No. 422.)

442. What is the international henry?

"The unit of induction shall be the henry, which is the induction in a circuit when the electromotive force induced in this circuit is one international volt while the inducing current varies at the rate of one ampere per second."

443. What is meant by a legal ohm?

The "legal ohm" was the temporary standard of resistance adopted by a committee of the International Congress of Electricians held at the Paris Exhibition in 1881. This was the standard from 1882 until 1894, and is equal to 1060-1063 international ohms. (See No. 433.)

444. What is meant by a legal volt?

The "legal volt" was adopted by the same committee, and bears a similar ratio to the international volt. (See also No. 435.)

445. What is the legal ampere?

The "legal ampere" had the same value as the international ampere. (See No. 434.)

446. What is meant by the "B. A." unit?

The British Association made a determination of the value of the ohm in 1863. This value was later found to be equal to 0.9863 international or true ohm.

447. What is meant by "Siemens' Units"?

The Siemens unit of resistance was originally proposed by Werner Siemens (a German electrician living from 1816 to 1892), being the resistance of a column of mercury one meter long and one square millimeter in section. This was in use in Germany for a number of years. It equals 0.9408 international ohm.

448. What is a "Weber"?

This name was given for some time to the unit of current, but has been abandoned for this purpose, the "ampere" being universally used for current measurement. The "weber" has been recommended for the practical unit of magnetic flux, being equal to 100,000,000 magnetic lines of force. The unit is named after Wilhelm Edouard Weber (1804 to 1891), a pioneer in the scientific study of terrestrial magnetism.

449. What is a "Gauss"?

The gauss is the C. G. S. unit of magnetic density, 10,000 gausses meaning 10,000 lines of force per square centimeter. The unit is named after Carl Friederich Gauss (1777 to 1855), who worked with Weber, and who invented the declination compass.

450. What is a line of force?

A line of force is the expression used to indicate either the direction or the strength of a magnetic force. The "unit magnet pole" is a magnetic pole of such strength that it will repel an equal pole with a force of one dyne when at a distance of one centimeter. Any magnetic field in which such magnet pole is attracted or repelled with a force of one dyne, is said to have a strength of one line of force per square centimeter.

451. How strong is the earth's magnetic field?

It varies in different places and at different times. In New York City the total field due to the earth's magnetism has a strength of about 0.61 line of force per square centimeter. This is in the direction of greatest force, which is about 72 degrees below the horizontal. The force in the horizontal direction, which is often called "horizontal intensity" or "H," is about 0.19, while the vertical component is about 0.58.

452. What is meant by "4 π" as used in connection with electricity or magnetism?

The Greek letter π (pronounced "pi") is a character adopted by mathematicians to denote the relation between the diameter and the circumference of a circle, and equals 3.1416; that is, the circumference of a circle is 3.14 times its diameter. The area of a sphere is 4 π (or 12.566) times the square of its radius, or π times the square of its diameter. For example, if the diameter of a circle is 6 inches, its circumference is 3.14 times 6, or 18.84 inches. The area of a sphere 6 inches in diameter is 3.14 times 6 times 6, or 113.1 square inches.

453. What does π have to do with electricity?

The exact relation is rather complicated and mathematical, but in general terms it comes from the original unit taken for magnetic force. At unit distance from a unit magnetic pole, the field has unit strength and there is one line of force per square centimeter. But there is an equal force in every direction from the unit pole, and since a sphere with radius equal to unity has a surface of 4 π, it follows that there are 4 π lines of force coming from a unit pole. In a more complicated way, the magnetic force due to a current flowing through a coil equals 4 π times the product of amperes by turns of wire

Queries and Answers

How can I determine the amount of water an engine uses from the amount of steam consumed? G. F. L.

The weight of water required is identical with the weight of steam consumed.

What is the best method of cutting the slots in the armature core of the motor described in the January and February numbers if complete punched discs cannot be obtained? J. C. V.

Procure plain round discs of the maximum diameter of the armature core, mount them on the shaft as described in the article and mill the slots on a milling machine. Then dismantle the core and smooth off any burrs around the edges of the slots; varnish the discs and reassemble the core.

Why are the transformers liable to greater damage by lightning when carrying current than when idle? P. Mc. N.

Because if lightning punctures the insulation when the transformer is carrying current the current will follow across the break and increase the damage, usually disabling the transformer. If there is no generator current to follow up the lightning discharge the damage is not likely to be so great, being only that due to the puncture, and if the transformer is insulated with oil the oil will usually heal the puncture made by the lightning.

Where can I obtain data for the construction of a small generator suitable for gas engine service? L. A. L.

Any 1/6-h.p. fan motor wound for battery current and driven as a generator will serve the purpose if used in connection with a sparking coil. If you wish to build a machine yourself the design for a 1/6-h.p. motor published in our issue of February, 1897, will give you the requisite information. The low-voltage windings for this machine, which you should use, were given on page 358 of the issue of September, 1897.

How should the motor described in the January and February issues be wound for a 500-volt circuit? R. B. W.

By using No. 27 wire for the coils of the cast-iron field magnet, making the coils 1¼ in. deep and 2 in. long, as specified in the article; for the cast-steel magnet the coils must be of No. 30 wire 1⅛ in. deep and 1⅞ in. long. The armature must be wound with No. 28 wire instead of No. 21 and instead of using 32 coils you will have to use 64. This can be accomplished by putting four half-coils in a slot instead of two as described in the article.

Can an induction coil be used for electric lighting? (2) Can the current from an induction coil be used for electro-plating? (3) Can I use a Wehnelt interrupter for an induction coil giving a 1½ in. spark and supplied with alternating current? W. G.

The transformers ordinarily used on alternating-current electric lighting and power circuits are induction coils. The chief difference between these and the apparatus ordinarily termed an induction coil is that in the latter the iron core is not continuous, whereas, in the transformer the core is a closed magnetic circuit. (2) No; electro-plating requires direct current and the current from an induction coil is alternating. (3) If you supply the primary of your induction coil with alternating current you will not require any interrupter or vibrator.

Can I operate two 110-volt lamps on a 500-volt circuit by using a resistance coil in series with them? W. F. M.

If you refer to enclosed arc lamps, it is probable that you would not be able to work them satisfactorily in series, as they are not built to be so operated and it is extremely difficult to so adjust two arc lamps in series on a constant-potential circuit that one will not rob the other. Even if the lamps regulated properly it would be exceedingly uneconomical to work them on a 500-volt circuit as you would be wasting over 60 per cent. of the energy applied to the lamp circuit.

Can an armature be tested in the manner described on page 417 of the issue of last September, by using the field magnet of the machine excited with alternating current and revolving the armature with the brushes lifted? S. J.

No; if alternating current is used in the exciting coil or coils the magnet must be laminated throughout and the field magnet of a dynamo is very seldom built so. A partial test may be obtained by exciting the field magnet from a separate direct-current source and driving the armature with the brushes lifted, but this does not give so severe a test as the method described, for the reason that each coil is only subjected to its own share of the total e. m. f. generated in the armature.

Should the series coils of a compound-wound dynamo be used when the machine is run as a motor? If so, would it not be of advantage to connect the series coils in series with the shunt coils and run the machine as a plain shunt motor? W. K. L.

A compound-wound dynamo may be run as a motor without changing any of the connections, in which case the series coils act differentially and tend to improve the speed regulation. A differentially-wound motor field, however, introduces disadvantages in commutation, so that your machine will probably work more satisfactorily if you cut the series coils out entirely. The number of turns contained in them would not add sufficiently to the shunt winding to justify the trouble of connecting them up in series with it.

Why is it that changing the lead of the brushes on a dynamo alters the output of the machine? G. I. K.

When the brushes of a bipolar dynamo are in the proper position the individual electromotive forces generated by the coils around one side of the armature from brush to brush are all in the same direction and this is true also of the other side of the winding. Now, if the brushes are shifted, say three commutator bars from the proper position, each half of the winding from brush to brush includes three coils in which the e. m. f. is in the opposite direction to that induced in the remaining coils so that the total e. m. f. is less than before, the result being the same as though six coils had been taken entirely out on each side.

How can a wattmeter measure the true watts in an alternating-current circuit in which there is inductance? C. S.

A wattmeter records the true watts because it is provided with two windings, one of which records the current value and the other the e. m. f. To comprehend the reaction of the coils upon each other consider the indication of the meter as merely instantaneous. For example, suppose that at a certain instant the e. m. f. is maximum and the lagging current has only 90 per cent. of its maximum value. Then the effect upon the meter coils will be that of the full e.m.f. and only 90 per cent. of the maximum current strength, so that the meter will indicate at that instant the true watts. If it does this at one instant it will do the same at all other instants, making the continuous record accurate.

Please inform me how I can rewind a 110-volt motor to run on a 230-volt circuit. (2) I wish to use the machine for driving an exhaust fan. Would the change be simplified by making it a series-wound machine? W. H.

For the field windings use wire having one-half the cross-sectional area of the present wire and make the coils exactly the same depth in inches from magnet core to the outer surface as at present. You can rewind the armature with wire one-half the present size or even one gage number smaller than half size, putting in as nearly as possible twice the number of turns per coil. (2) The machine could be more easily reconstructed if changed to a series-wound motor. In this case the field winding should be of wire about the same size as that now on the armature and the armature need not be rewound at all. A rheostat may be required in series with the motor.

How can I determine approximately the output of a small 110-volt dynamo, not knowing its rating? A. K.

You can obtain a rough idea of the heating limit of the armature by noting the size of the armature wire and assuming that for each 100 circular mils of area in a single conductor the machine will maintain one lamp. Thus, if the armature coils consist of No. 10 wire wound singly the area in circular mils is 10,380, which means that the machine will maintain approximately 100 lamps. Having ascertained roughly the number of lamps that the armature will probably supply, connect the machine up to this number and run it for an hour and then test the temperature of the armature with a thermometer. If the rise in temperature above the surrounding air exceeds 75 deg. F. the machine is overloaded. By successive trials until the rise of temperature after an hour's run is from 65 to 75 deg. F. you can obtain the normal output of the machine.

A MULTIPLE-SOLENOID SYSTEM OF CONTROLLING PRINTING PRESSES.

The motors used for driving large multi-cylinder rotary presses for daily papers must meet several difficult requirements. Besides accelerating the presses smoothly at a fixed rate up to speed, they must be able to run them at extremely low speeds, stopping with precision after very short motions, such as a fraction of a revolution of the press cylinder. This is a duty the electric motor with rheostatic control is inherently ill adapted to perform, as the heavy current necessary to overcome the friction of the rest of the complicated mechanism of a printing press tends to accelerate the press rapidly after the first instant of starting. Printing presses frequently require very different amounts of power at different portions of the press cycle; thus the power required to start at one position may cause racing at another. The problem is by nature one of the controller, and one requiring controllers of unusually elaborate design in order to meet all the varied and somewhat conflicting requirements.

While the mechanism described below, made by the Cutler-Hammer Manufacturing Company of Milwaukee, Wisconsin, may seem somewhat elaborate, this elaboration is apparently well warranted by the size, importance and needs of large rotary presses and by the way in which the controlling mechanism described meets these varied needs automatically with the simplest guidance of the pressmen.

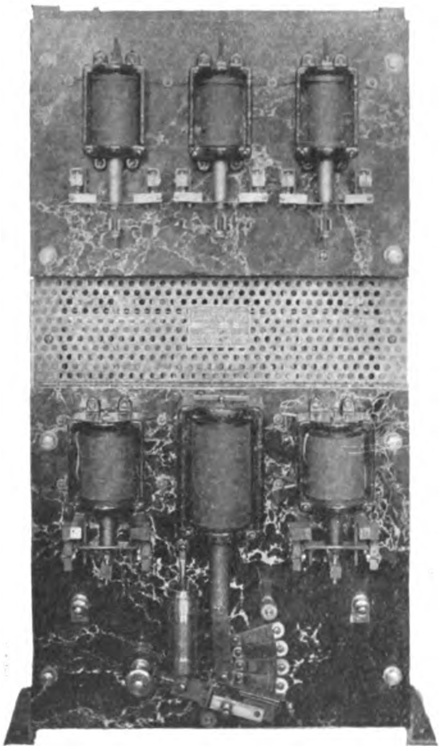


FIG. 2.—LOW-SPEED GOVERNOR.

Before taking up the details of the solenoid system itself, it may be well to explain the method of obtaining very slow speeds (such as 5 per cent. of normal) used both in this system and others developed by the Cutler-Hammer Manufacturing Company. The low speeds are obtained without independent sources of low-voltage current, such as motor-driven teasers, but by shunting the motor armature with a resistance connected directly across the brushes, the armature in shunt with this resistance remaining in series with the usual starting rheostat across the line. A simple diagram of the connections is shown in Fig. 1. It will be readily seen that this, in a sense, places the armature across a more or less constant potential, consisting of the drop in the armature and its shunt resistance, which, in series with the drop in the starting box or controlling resistance, makes up the total potential difference of the line. If the resistances in series and in shunt with the armature allow considerable current to pass from line to line compared with that needed to turn the armature, any variation of the load will not materially affect the difference of potential across the armature, and consequently will not affect the speed to any considerable extent. This is true because the potential across the brushes will remain (to assume a definite case) at nearly 5 per cent. of the potential between the lines if the resistance in shunt with the armature is 5 per cent. of the resistance in series with it. If the shunt and series resistances are made high so as to economize current, the speed regulation will be less definite; but even with high enough resistance to avoid serious waste in the shunt around the armature, the speed control can readily be made sufficiently close for all practical purposes. The waste in this shunt is not as serious as might at first appear, as the shunt takes no power except when the press is actually running at very low speeds, and there is no constant waste in auxiliary apparatus such as there is in teaser systems.

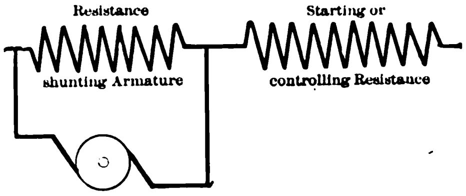


FIG. 1.—CONNECTIÓN FOR SLOW SPEED.

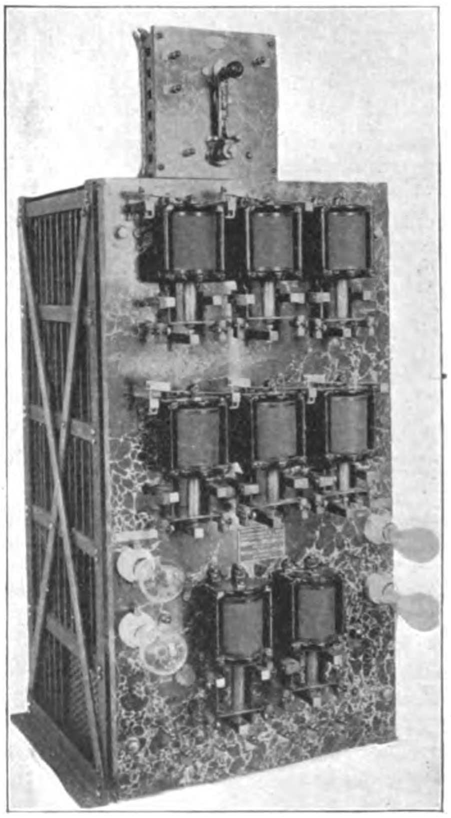


FIG. 3.—ACCELERATING STATION, WITH STARTING SWITCH ABOVE.

In the multiple-solenoid system the resistance forming the shunt is automatically controlled by means of solenoids. As soon as the speed of the armature rises to the proper point the shunt resistance is automatically connected across the armature brushes by means of what is termed a "slow-speed motor governor." One of these devices for motors ranging in size from 15 to 25 h.p. is shown in Fig. 2. At the top may be seen three solenoids, the coils of which are connected in series with each other and across the armature terminals of the motor so as to be excited in proportion to the difference of potential between the brushes. These solenoids are termed "wall controllers." Each wall controller acts simply as a relay, its contacts closing a circuit through the winding of the corresponding one of the three lower solenoids shown in the same illustration. The plunger of the left-hand lower solenoid closes the shunt circuit around the armature when pulled up. The middle solenoid (which is the motor governor proper) operates a hinged arm or lever which cuts in or out sections of the resistance in shunt with the armature. When the motor nearly reaches the speed to which the governor is supposed to limit it, the left-hand wall controller operates, bringing up the left-hand solenoid, closing the shunt; next the middle wall controller becomes sufficiently excited by the counter e.m.f. across the brushes to lift its plunger, which energizes the solenoid of the motor governor proper, which, in turn, gradually lifts its plunger against the dash pot, reducing the resistance in shunt with the armature until so much current is shunted through this resistance that the armature ceases to accelerate any further and again slows down. The counter e.m.f. of the armature then falls, the middle wall controller lets go, the motor governor begins to fall by gravity—being retarded by the dash pot—and the resistance in shunt with the armature is gradually increased again, step by step, until the armature again accelerates, pulling up the wall controller and causing the shunt resistance to be reduced again. The apparatus consequently see-saws, maintaining the resistance in shunt with the armature at the proper point to hold the armature at the desired speed, no matter what the load upon it may be. The connections of these parts with the motor are given in the upper left-hand corner of the general diagram of connections of the whole system, Fig. 4.

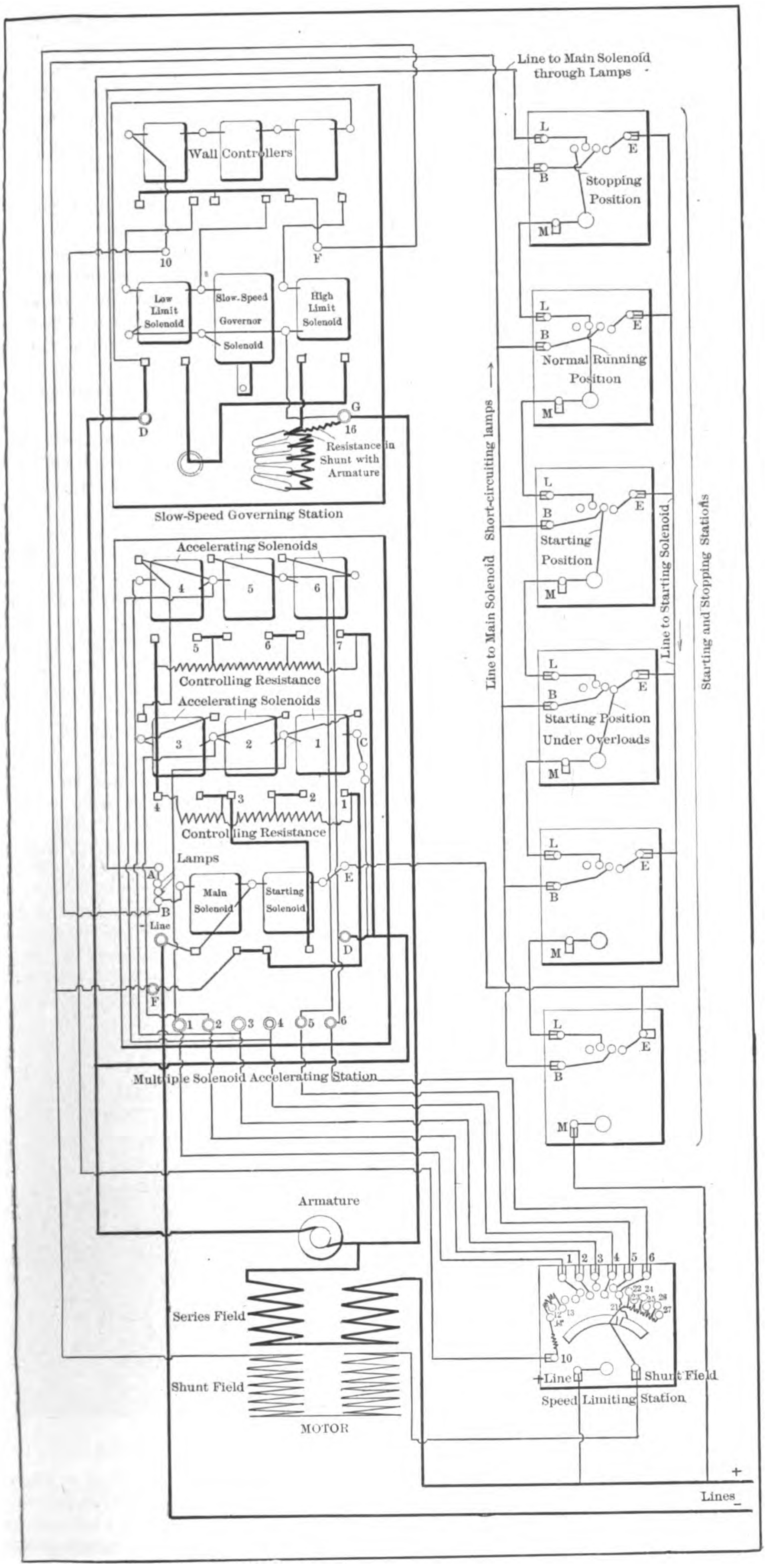

Line to Main Solenoid through Lamps
Wall Controllers
10
F
Low Limit Solenoid
Slow-Speed Governor Solenoid
High Limit Solenoid
D
G
16
Resistance in Shunt with Armature
Slow-Speed Governing Station
Accelerating Solenoids
4
5
6
7
Controlling Resistance
Accelerating Solenoids
3
2
1
C
Controlling Resistance
Lamps
A
B
Line
Main Solenoid
Starting Solenoid
E
D
F
Multiple Solenoid Accelerating Station
L
B
E
M
Stopping Position
Normal Running Position
Starting Position
Starting Position Under Overloads
Line to Main Solenoid Short-circuiting lamps
Line to Starting Solenoid
Starting and Stopping Stations
Armature
Series Field
Shunt Field
MOTOR
+Line
Shunt Field
Speed Limiting Station
+
Lines
_

FIG. 4.—COMPLETE DIAGRAM OF CONNECTIONS.

The purpose of the right and left-hand wall controllers, with their corresponding solenoids, is to do the work quickly without waiting for the slow-acting governor, whose motion is retarded by the dash pot. For example, if a sudden load were thrown upon the motor, the governor proper would not increase the resistance across the armature terminals fast enough to prevent the motor from stopping. The controller on the left, in this case, acts ahead of the governor, dropping its contacts, which open the circuit of the solenoid on the left, its plunger opening the shunt around the armature and preventing the motor from stopping. In case the motor load falls off greatly and the speed tends to rise too readily for control by the dash-pot governor, the controller on the right picks up its contacts, causing the corresponding solenoid to rise, short circuiting all the resistance steps of the governor proper, reducing greatly the resistance of the shunt around the armature and preventing any further rise of speed. Thus the right and left-hand controllers and corresponding solenoids are what might be called "high and low limits," which anticipate the action of the more sluggish and more exact governor proper. The motor is thus held automatically down to speeds suitable for "making ready," no matter what the load may be or how it may change from instant to instant.

For obtaining higher speeds, this slow-speed motor governor is thrown out of action, removing the shunt around the motor armature, leaving the armature in series with the usual controlling resistance. Instead of connecting the various steps of this controlling resistance to the segments of a manually-operated contact arm, the steps are connected to the contacts of a multiple-solenoid acceleration regulator. One of these machines of the 15-h.p. size is shown in Fig. 3. The one shown has six multiple solenoids for cutting out steps of the controlling resistance, these six being mounted in two rows of three each across the face of the panel. The windings of these six solenoids are connected in series with each other and with a lamp resistance across the armature of the motor. When the motor is started, the windings of all of these six solenoids, except the first one, are short circuited by means of carbon contacts above the solenoid frames. The contact above the first solenoid short circuits the winding of the second, and the contact in that solenoid short circuits the winding of the third one, and so on through the series, there being no short circuiting contact on the last one.

As the motor speed and counter e.m.f. rises, the first solenoid pulls up its plunger, cutting out one section of the controlling resistance, and also opening the short circuit around the winding of the second solenoid. This is so weighted that it does not pull up its plunger until the counter e.m.f. of the motor reaches a considerably higher value than that required to operate the first solenoid, after which the second one operates, cutting out another section of the controlling resistance and opening the short circuit around the winding of the third solenoid, this action continuing until all the solenoids have operated, cutting out all of the resistance in series with the motor armature and connecting the latter straight across the line.

There will be noted on the lower part of the multiple-solenoid accelerating station, shown in Fig. 3, two other solenoids, one of which (termed the main solenoid) is for throwing the motor in circuit when starting, or out of circuit when stopping. Its winding is connected in series with two incandescent lamps directly across the line. These lamps have sufficient resistance to keep the solenoid from lifting, but will allow sufficient current to pass to hold the plunger up after the solenoid has once lifted it. The solenoid is made to lift its plunger by short circuiting the two lamps, thus connecting the solenoid winding directly across the lines. The circuits of these devices are shown in Fig. 4. This connection can be made at any one of a number of starting and stopping stations—as many as may be desired scattered around the press—one of which is shown mounted on top of the multiple solenoid in Fig. 3. By moving the handle of this starting and stopping device to the right the lamps are short circuited, pulling up the starting solenoid, closing the main circuit from the line to the motor, after which the automatic devices take charge of the control, accelerating the speed smoothly and at a predetermined rate up to normal. The handle of the starting and stopping device is moved back by a spring as soon as released, resting normally on a contact which leaves the winding of the main solenoid in series with the two lamps, holding the plunger of this solenoid in the closed position. By moving the handle of any starting and stopping station to the left, the circuit through the main solenoid is broken, cutting off current from the motor, stopping the latter and allowing the automatic solenoids to resume their normal positions.

There is a fourth position provided for the starting and stopping lever which operates the other solenoid shown on the lower part of the speed regulator station, Fig. 2. This starting solenoid short circuits two sections of the controlling resistance and thereby provides a means of positively starting the motor in case its load is so great that it will not start with the usual controlling resistances in series with it.

There is, in addition, what is termed a "speed limiting station," indicated in the diagram, Fig. 4. By placing the lever of this station on the extreme left-hand button, the slow-speed governor mentioned above will throw in its shunts around the armature and automatically compel the armature to operate at the slowest specified speed. With the lever on the second button the motor will operate a little faster, and on the third button still a little faster, due to the resistance inserted in series with the solenoids of the slow-speed governor. If the lever of the speed-regulating station is set over further to the right the motor governor does not come into action at all, no shunts being connected around the armature to limit its speed to a low figure. The several further positions of the speed-limiting lever cut out respectively the six solenoids of the multiple-solenoid regulator, thus stopping the action of these multiple solenoids at a motor speed determined by the position of the speed-limiting lever. The speed-limiting lever can be left at any position, either on the contacts bringing into action the slow-speed governor, or on those bringing in the multiple-solenoid regulator, and the starting can be accomplished from any of the starting stations by one quick movement of any of the starting levers, the automatic apparatus then taking hold and bringing the motor up to the speed determined by the position of the speed-limiting lever.

Even if the speed-limiting lever is suddenly moved up from a low-speed to a high-speed position the motor is not suddenly speeded up since the solenoids gradually accelerate the speed in any case. The speed-limiting station is also provided with a resistance for insertion in series with the shunt field of the motor for the purpose of obtaining the highest speeds desired.

NEW OFFICE BUILDING OF THE WESTINGHOUSE ELECTRIC & MANUFACTURING CO.

Six years ago when the Westinghouse Electric & Manufacturing Company removed its works from the city of Pittsburg to East Pittsburg, 12 miles distant from the city, it was proposed to erect a separate building for offices, but as a temporary resource part of the second floor of one of the manufacturing buildings was appropriated for office purposes.

About a year ago it was determined to erect permanent offices which should be of sufficient size to afford accommodation for the staff of the numerous departments of the business.

The building just completed is located at the western end of the main works. It is 250 feet by 50 feet in plan, with a height of seven stories.

A novel feature has been introduced by devoting one entire end of the building to fireproof vaults. Twenty-four feet from the outer wall a fireproof brick wall is carried upward from the foundation to the roof, forming fireproof vaults upon the several floors, each having an area of 1200 square feet. Entrance to these six vaults is through two sets of double fireproof iron doors on each floor.

Upon the second and third floors are the private offices and suites of rooms devoted to the business, sales and other departments except the engineering departments. The entire fourth floor is occupied by the mechnical engineering department and by the draughtsmen. The fifth floor is similar to the fourth, but contains the quarters of the electrical engineering department.

The office building stands immediately across the western end of the main shop, the center bay of which is commonly known as "the main aisle." This main shop was extended 200 feet toward the west last year and another extension at the other end of 250 feet toward the east is at present being completed. This gives the main shop a total length of 1,200 feet. Work has also been commenced on an extension of what is known as the warehouse (the large building parallel with the main shop but nearer the railroad) which will also be extended 200 feet toward the west, bringing its western end again opposite that of the main shop. The space, about 65 feet wide and 1,200 feet long, between the main shop and the warehouse, will then be roofed over and provided with craneways, higher than those in the main aisle, so as to accommodate large machines, the diameters of which are so great that there not sufficient room vertically for them in the present main aisle. This will make the works one large building about 1200 x 375 feet in size, with a floor space of about 11½ acres, including galleries. The number of employees at the works is now about 5,500.

OFFICE BUILDING AT THE WESTINGHOUSE ELECTRICAL WORKS.

New Apparatus and Appliances

A CORRECTION.

In this department of the March issue the desk telephone set, illustrated by Fig. 5, on page 152, was said to be manufactured by the "Chicago Telephone Company," of Chicago. This should have read the "Chicago Hotel Telephone Company," the word "Hotel" having been dropped inadvertently.

THE PLAYFORD MECHANICAL STOKER.

It is coming to be generally recognized by users of steam in either large or small quantities that mechanical stoking gives far better economy, everything included, than does hand firing.

In the burning of cheap bituminous coal the fuel should be introduced to the front of the furnace so that the combustible products driven off by the coking process will pass over the incandescent body further to the rear and be burned thereby. The simplest of mechanical stokers accomplishing this result is the chain-grate type, but the simple chain grate is subject to several disadvantages, particularly the burning out of the chains.

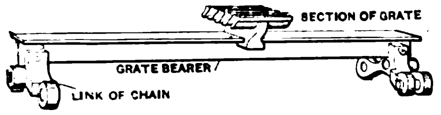


FIG. 1.—GRATE BEARER AND SECTION OF GRATE; PLAYFORD STOKER.

The stoker illustrated in the accompanying drawings and made by the Playford Stoker Company, Cleveland, Ohio, is of the chain-grate type, i.e., the grates are carried by chains into the furnace at the forward end and out from it at the rear end; but it presents many advantages over the plain chain grates, one of the most notable of which is the use of removable grate bars which can readily be taken off from the chains. The chain mechanism is supported on the usual carriage, which can be readily rolled out on a track to bring the whole grate into a position in the fire room convenient for repairs.

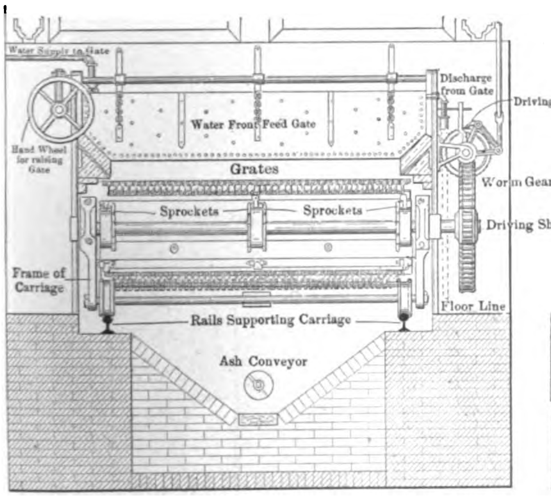


FIG. 2.—FRONT ELEVATION OF PLAYFORD STOKER AND SECTION ACROSS ASH-PIT.

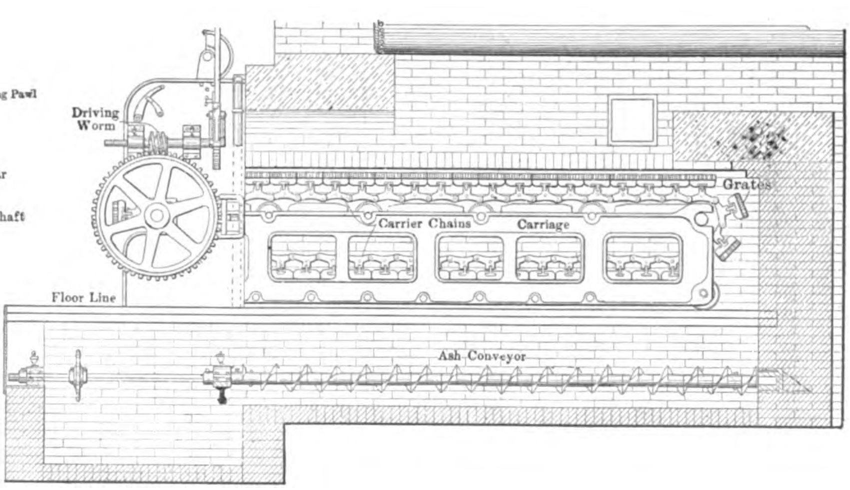


FIG. 3.—LONGITUDINAL CROSS-SECTION OF PLAYFORD STOKER, IN THE VERTICAL PLANE.

Running across the front end of the grate is a heavy driving shaft operated by a ratchet mechanism or a worm and gear. This driving shaft, carrying two or more sprockets (according to size of stoker), is shown in the front elevation. Over these sprocket wheels and over idlers on another shaft at the rear of the grate there run two or more lines of sprocket chains, one down each side of the furnace, which thus differs essentially from the chain-grate furnace in not having a continuous web of chains clear across the whole width. The links of these chains are slotted and carry steel T-bars which run across the furnace and serve as grate bearers. This arrangement is plainly shown in the detail view. Each of these grate bearers in turn carries a number of grate sections, each about 1½ in. by 6 in. in size; one of these sections being mounted on the grate bearer in the detail view. All the sections on one grate bearer may be removed by taking out one cotter pin, and this may be done without disturbing the fire. These grate sections can be made in any foundry. The division of the grate surfaces into sections gives flexibility and takes out the strains due to expansion and contraction. The grate sections are so made that they are well exposed to air and therefore have a long life.

The admission of fuel in front of the furnace is controlled by a gate which is water cooled, and which may be raised or lowered at will by a hand wheel. This gate regulates the thickness of the bed of fire, and further regulation can be obtained by adjusting the speed of the driving mechanism by a ratchet regulator or cone pulleys. The gate prevents back-firing of coal in the feed hopper. The water which passes through the gate may be, if desirable, piped to an open heater. Longitudinally in the furnace setting is placed a screw ash conveyor, which is driven by a chain and sprocket, from the same source of power that drives the stokers.

At the front of the furnace, immediately above the coking end of the grate surface, is a fire-brick arch made of common-sized fire brick, obtainable in any market. The arch becomes heated intensely, making the front end of the furnace a reverberatory chamber in which the gases are liberated from the coking fuel—by the process of destructive distillation—and is the main factor in producing smokeless combustion. The coked fuel in process of combustion is carried by the travel of the grates toward the rear of the furnace; ash and refuse are dumped (automatically) under the flat arch at the bridge wall and conveyed to the front of the boiler by the ash conveyor.

A SMALL GASOLENE FIRE-POT.

A new gasolene fire-pot or soldering-iron furnace has been brought out recently by the Clayton & Lambert Manufacturing Company, of Detroit, Michigan. This furnace, which is illustrated by Fig. 4, is smaller than the usual type, being made of such a size that it can be carried in the tool-bag ordinarily used by linemen and plumbers. Notwithstanding its small size, the furnace is capable of doing the same character of work as that done by larger furnaces, the chief difference being that the tank does not hold quite so much gasolene; it contains however, sufficient gasolene to last through an ordinary day's work. The flame, it is stated, is sufficiently powerful to heat a pair of coppers and a pot of metal at the same time. The top section of the furnace may be removed by taking out a spring key in the center pipe, so that the flame may be exposed and the furnace used as an ordinary torch.

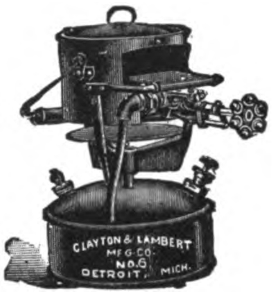


FIG. 4.—GASOLENE FURNACE, PORTABLE IN A TOOL-BAG.

STILWELL CAST-IRON HEATER.

Fig. 6 is an exterior view of a cast-iron feed-water heater built by the Stilwell-Bierce & Smith-Vaile Company of Dayton, Ohio, for handling water containing acids, salts or other impurities which injure wrought-iron and steel. Fig. 5 shows vertical and horizontal cross-sections. The exhaust steam upon entering the receiving chamber, impinges upon a curved deflecting plate (see upper part of Fig. 5) which is provided with grooves, and the function of which is to separate the cylinder oil from the steam, carrying the oil to sides and bottom of the chamber, when it emerges through the opening marked "oil discharge." This deflecting plate also carries the steam downward, as indicated by the arrows, to the two rectangular openings through which the steam passes into the heating chamber. The construction of the receiving chamber is such as to prevent shock and "breathing" of the heater, which would result from admitting the exhaust from high-pressure engines direct into the heating chamber.

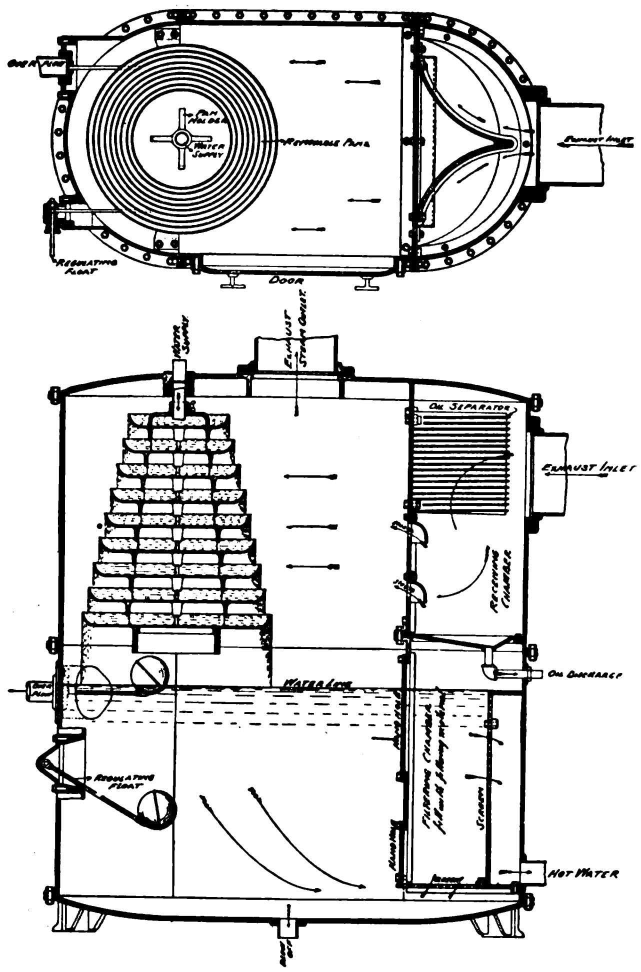


FIG. 5.—CROSS-SECTIONS OF STILWELL HEATER.

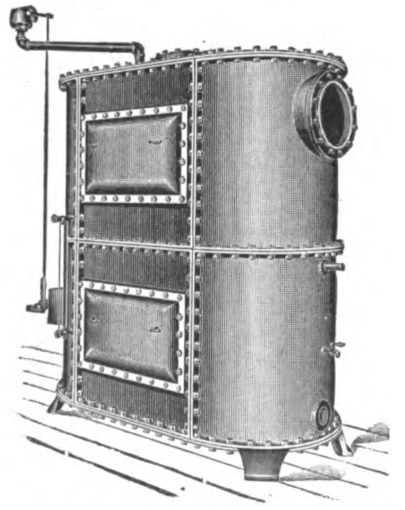


FIG. 6.—NEW CAST-IRON HEATER.

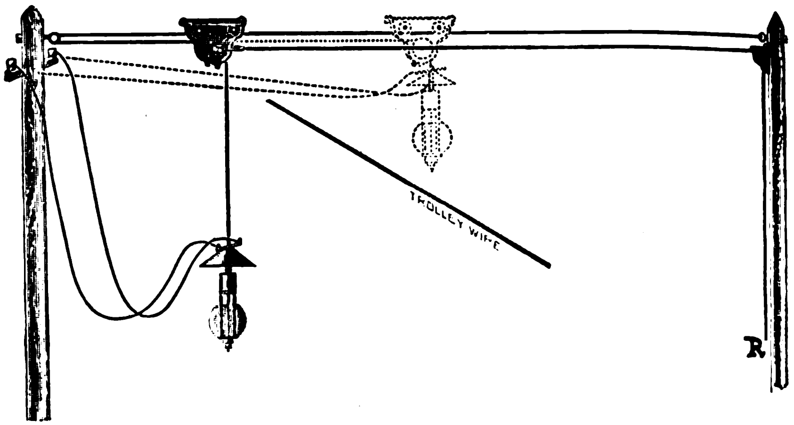


FIG. 7.—SEMI-AUTOMATIC ARC LAMP SUSPENSION PULLEY.

Leaving the receiving chamber through the rectangular openings, the exhaust steam enters the heating chamber in two streams, coming in contact with the feed water falling in sheets over the edge of the oval-shaped pans. The uncondensed steam escapes freely from the top of the heater, and the construction is designed to prevent carrying water out with the escape steam. The lower portion of this heating chamber is a reservoir of large capacity filled with hot water. It also serves as a settling chamber and a receptacle for the condensation returned from radiators or heating coils used on the premises. This chamber is provided with two floats; one for regulating the inflow of feed-water and one for regulating the overflow, thus affording a double safeguard against flooding the heater.

Below the receiving chamber is a filtering chamber, in which the hot water is filtered upward, the filtering screen being located in the upper part of a partition which separates the outlet from the unfiltered body of hot water.

C. E. ARC LAMP SUSPENSION.

A rather ingenious arrangement for withdrawing an arc lamp from the center of a span-wire to one side and lowering the lamp at the same operation is marketed by the Creaghead Engineering Company, of Cincinnati, Ohio, and represented by Fig. 7 herewith. The suspension pulley travels along a span-wire in the usual manner. From the left-hand pole in the illustration a flexible cable, or rope, as preferred, is carried out, through the suspension sheave and to the hanger of the lamp. The controlling rope or cable is made fast at one end to the frame of the suspension pulley and runs through a sheave on the right-hand pole, down to within reach of the trimmer, at R. Inspection of the engraving shows that when the lamp is in the position shown, pulling on the rope at R will haul the traveling sheave out to the middle of the span-wire and as it moves outward the lamp will be drawn up to the position indicated by dotted lines. Conversely, when the rope is released at R the lamp will drop by its own weight, and in dropping will pull the traveling sheave over to one side by means of the suspension rope.

A NEW NAVY-STANDARD PROJECTOR.

The Rushmore Dynamo Works of Jersey City, N. J., has brought out a new line of searchlights known as "navy-standard" projectors, one of which is represented by Fig. 8. These projectors are built for torpedo-boat destroyers and similar service and are provided with 18-

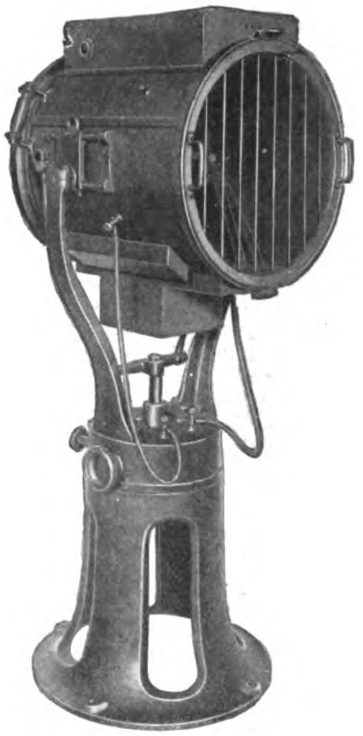


FIG. 8.—NAVY-STANDARD PROJECTOR.

American Electrician.

Vol. XII. New York, May, 1900. No. 5.

ELECTRICAL EQUIPMENT OF A MAMMOTH PACKING HOUSE.

The Motive Power and Refrigerating Plant of the Armour Establishment.

BY J. E. SMITH.

For those who have never had an opportunity of visiting a large packing establishment, an idea of the proportions of the great Armour plant in Chicago may prove interesting; it will, at least, enable the reader to get a better conception of the relative values of the new power equipment and the old methods of producing heat, light, power and refrigeration. An L-shaped area of sixty-five acres is covered by buildings ranging from two to ten stories in height and divided into fifty-two distinct departments, each of which is operated as a separate institution. The daily slaughtering capacity of this plant is 15,000 hogs, 3000 cattle and 7500 sheep and calves. It has often been truthfully said that nothing is lost in the packing business but the squeal of the pig, and this, I understand, has recently been preserved, by a progressive packer, to be exhibited at the Paris Exposition through the medium of a gramophone.

In the cutting of a hog, the loin goes in one direction, the sides in another, the hams, shoulders and bacon in another, the feet, the head, the fat and trimmings, in fact, every part is taken to a separate department for some special purpose. This cutting supports the pickling department, which, in turn, furnishes material to the smoked meat department, and so on. The canning, sausage, lard, ham, pigs' feet and tripe, extract, pepsin, dry salt, sweet pickle, hide, oleo and wool, fertilizer, cooperage, tin and printing constitute the principal manufacturing departments, and from the last three all the packages, except the boxes, that are used are made on the ground, as are also the labels and other printed matter necessary to carry on this extensive business. An electric elevated road encompasses the entire establishment, and four motor cars are kept busy plying between the packing and shipping departments.

The machinery department of this institution, before installing the new equipment, consisted of eighty-nine multi-tubular boilers 60 inches in diameter and 18 feet long and four Stirling boilers of 400 h. p. capacity each; 16 power engines,

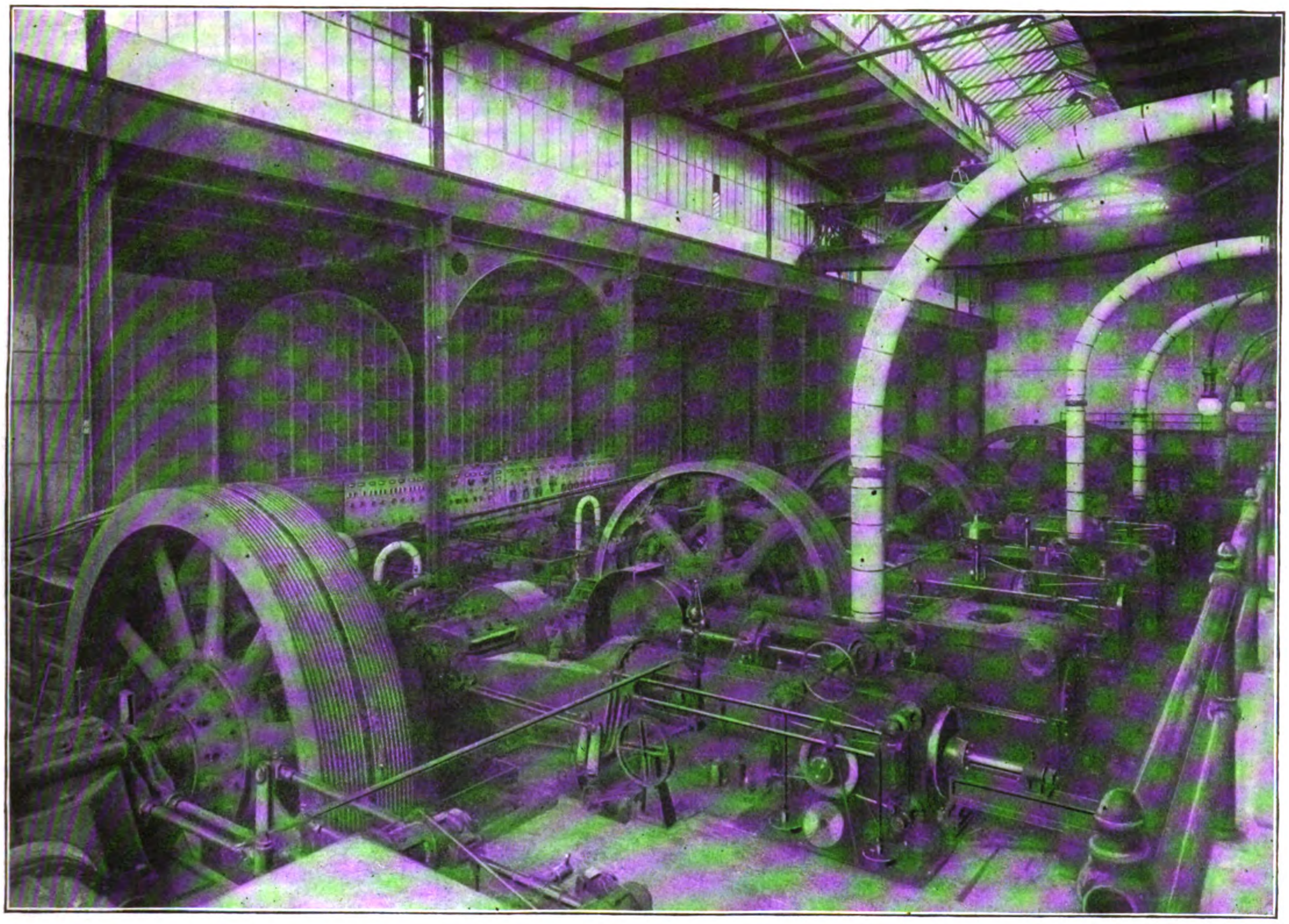


FIG. 1.—DIAGONAL VIEW OF ENGINE AND GENERATOR ROOM.

ranging from 25 h. p. to 600 h. p., and 17 refrigerating machines of from 75 to 100 tons capacity each. The plants were scattered, and located without regard to facilities for handling coal or ashes or thought of economical attention. They were, for the most part, small, and, in many places, were found to entail too much work for one man and not enough for two. Coal and ashes had to be handled with wheelbarrows and carts, and the cost of keeping the streets in repair so that a horse could haul a specific load was by no means a small item of expense. The refrigeration was performed by what is known as the brine system, and as the tanks were all built of wood upon the ground there was considerable loss of salt by leaks, with no possible way to avoid it except to either build new ones or avoid their use by adopting the direct-expansion system. There are employed, in the entire establishment, about 7000 workmen; of this number, 147 were required in the

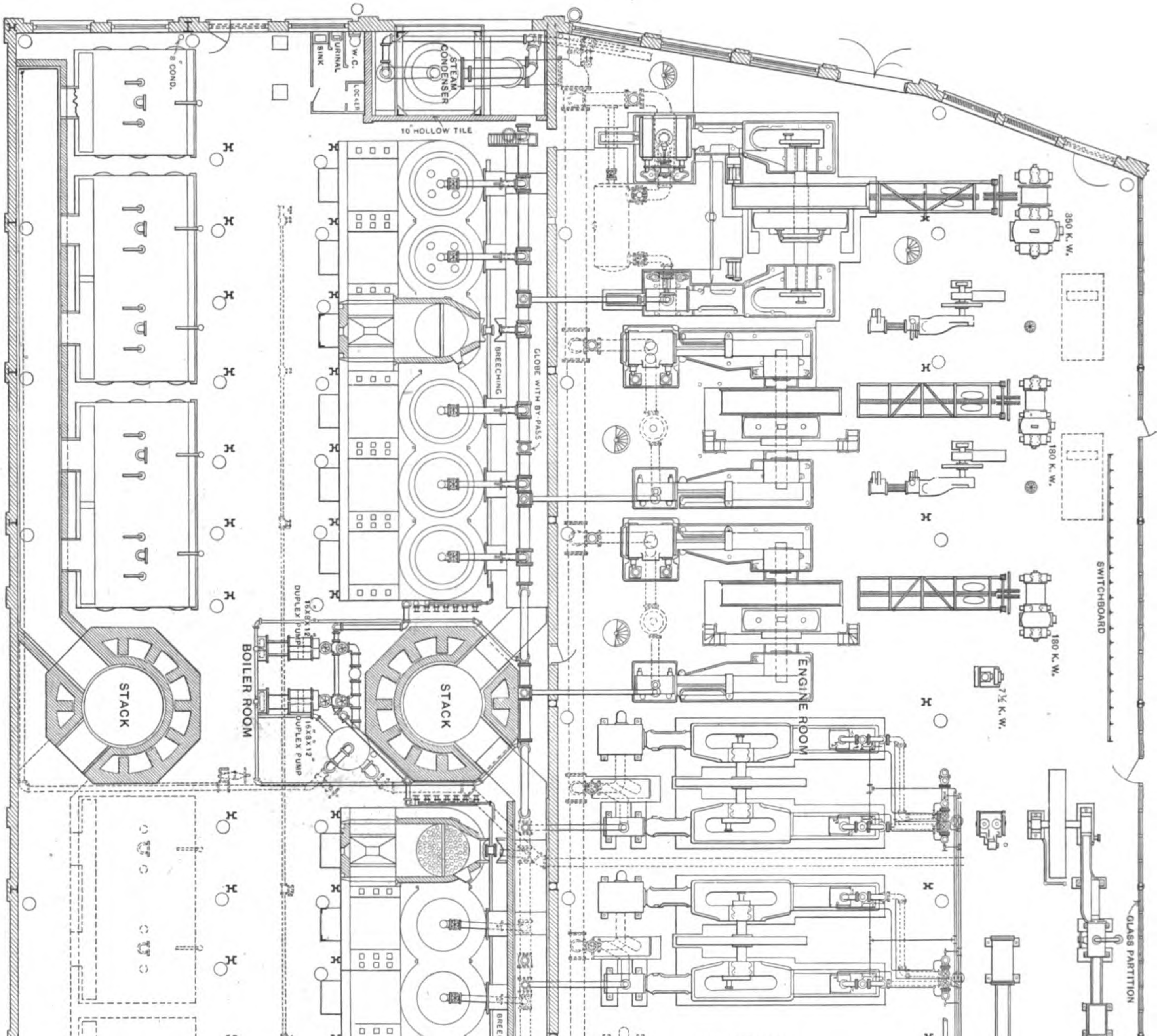

W.C.
URINAL
SINK
LOCKER
STEAM CONDENSER
8 COND.
10" HOLLOW TILE
BREECHING
GLOBE WITH BY-PASS
16x8x12 DUPLEX PUMP
BOILER ROOM
STACK
STACK
16x8x12 DUPLEX PUMP
BREECHING
9 X 12 ELECTRIC TRIPLEX PUMP
9 X 12 ELECTRIC TRIPLEX PUMP
8 COND.
8 COND.
ENGINE ROOM
350 K.W.
180 K.W.
180 K.W.
7½ K.W.
SWITCHBOARD
GLASS PARTITION
American Electrician

FIG. 2.—FLOOR PLAN OF BOILER AND GENERATOR ROOMS, ARMOUR POWER STATION.

operation of the motive power department.

That large industries recognize the advantages offered by the concentration of power generation is evident from the number of electric power plants that are now in use. The new plant of Armour & Co., which recently began operation, comes under the head of creditable equipments of this class, and is now the most attractive feature of the stock yards district. The substituting of electrical power for steam was not attended by any very serious obstacles, as the motors were all installed ready for the belts before the engines were disturbed, but the changes made necessary by the conversion of the refrigerating system from brine to direct expansion was a very troublesome operation, as it necessitated the removal of every foot of pipe, rendering the storage rooms unfit for use during the change. To avoid serious complications, this work was pushed vigorously during the winter months when the temporary loss of one or two coolers could be provided for.

The power station covers an area 200 feet square and is of steel construction, four stories high on the west side, the top of iron work being 103 feet above the ground. The building provides accommodations for the entire machine department in every branch. The store room occupies a portion of the first floor and basement; the machine shop will occupy the second floor; the third floor is used for the ammonia condensers, and the fourth floor for the water cooler. The outside walls of the building are of brick. The wall dividing the boiler-room from the engine-room is of brick up to the bottom of the crane girder; from that point to the ceiling, it is of hollow tile. The partition between the engine-room and store-room is composed of 7 feet of brick wall and 22 feet of wire glass in galvanized iron frames. Partitions on machine shop floor are of tile and wire glass. Skylights are made of concrete curbing and wire glass, with ample ventilators to provide good circulation of air. The roof and all floors are made of concrete, supported by iron rods spaced and proportioned suitable to the span, these rods being covered with a wire cloth of No. 13 gauge and 2½-inch mesh. The roof is composed of 3 inches of cinder concrete, covered with a composition of felt, tar and gravel.

The machine-shop and store-room floors are made of stone concrete, between wooden sleepers, and covered with 1½-inch maple flooring; the condenser and cooler floors are made in the same manner except that the sleepers are left out and an asphalt basin an inch thick is put on top of the concrete. The engine-room floor is also of stone concrete, laid off in 13-inch squares, with a 3-inch red tile across the corners; this floor gives a very handsome effect, as seen in Figs. 1 and 5. The basement floor is about 3 feet below the sewer line, and deluge is averted by a network of porous tiling leading into sumps, which are provided with automatic electric bilge pumps; this floor is also of concrete and is perfectly dry. The engine-room floor behind the engines is iron grating; this flooring is made in sections, so that it can be readily removed, as it is laid immediately over the main exhaust pipe and its removal may be found necessary almost any time; it also provides for ventilation in that part of the basement.

The walls of the engine-room are plastered and have a sand finish down to the wainscoting, which is finished in Portland cement and polished. Stairs and walks are all of iron. Ceilings and walls are painted white, and the steel work yellow to the wainscoting. Below this the walls, engines and generators are painted a dark

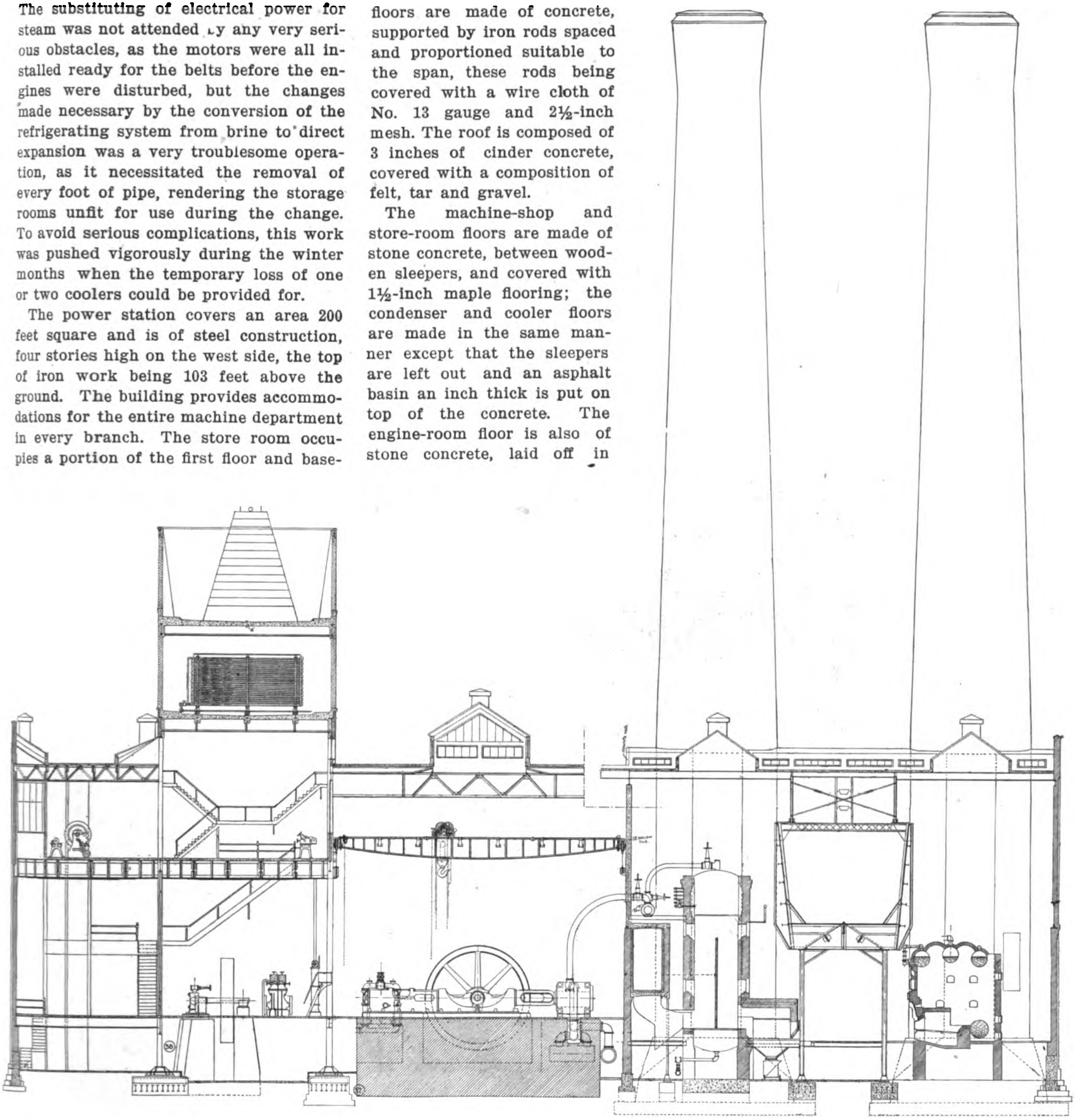


FIG. 3.—VERTICAL CROSS-SECTION THROUGH ARMOUR POWER STATION.

green and striped with gold. The whole effect is pleasing without reaching the gaudy state. Twelve feet above the floor, on the east and north walls, is a gallery 4 feet wide provided to give the visitors an opportunity of seeing the station. Fig. 1 is a view taken from this gallery at the southeast corner of the engine-room.

Fig. 2 is the floor plan, showing the general arrangement of the plant. The station, when completed, will have 9000 h. p. of boilers, 4000 h. p. of electrical machinery, 2100 tons daily refrigerating capacity; air compressors with a capacity of 4000 cubic feet of free air a minute and a water-pumping capacity of 10,000,000 gallons a day. The present installation embraces 4500 h. p. of boilers, the total electrical equipment, refrigerating machinery of 900 tons capacity, the whole pneumatic system, about one-half of the water-pumping capacity and a Weiss condenser, built by the Southwark Foundry & Machine Company, of Philadelphia, and having a capacity of 1500 pounds of steam a minute; the location of this condenser is at the south end of boiler-room, as shown in Fig. 2. As will be seen in this plan, the electrical machinery occupies the south half of the floor, good views of which are given by Figs. 1 and 5; the latter was taken from the southwest corner of the engine-room and shows to good advantage one of the auxiliary engines used in connection with the Weiss condenser; also the method of driving the alternating machines. The north half of the floor is occupied by refrigerating machines and the air compressors.

Fig. 3 is a section through the building just north of the center. The coal-handling machinery, which is not shown (except above the bunkers in Fig. 3), consists of two scraper conveyors, 160 feet long, supported on steel standards between the building and the railroad track. The coal is shoveled from the cars and carried into a crusher, where it is reduced to uniform size; it is then elevated into the bunkers by a combined bucket elevator and conveyor. The coal-handling machinery was furnished by the Berghoefer Machinery Company, of Milwaukee, Wis. There are two sets of coal bunkers (one for each two batteries of boilers) having a capacity each of 600 tons; the bunkers are supported by heavy steel columns on foundations of steel and concrete and are cantilevered over stack foundations, so as to avoid any connection between them. They are located at a height sufficient for easy gravity discharge of coal through chutes into the magazines of the mechanical stokers, which were built by the Murphy Iron Works Company, Detroit, Mich.

The stokers are equipped with double sets of engines, one on each corner of each battery, so that either set may be

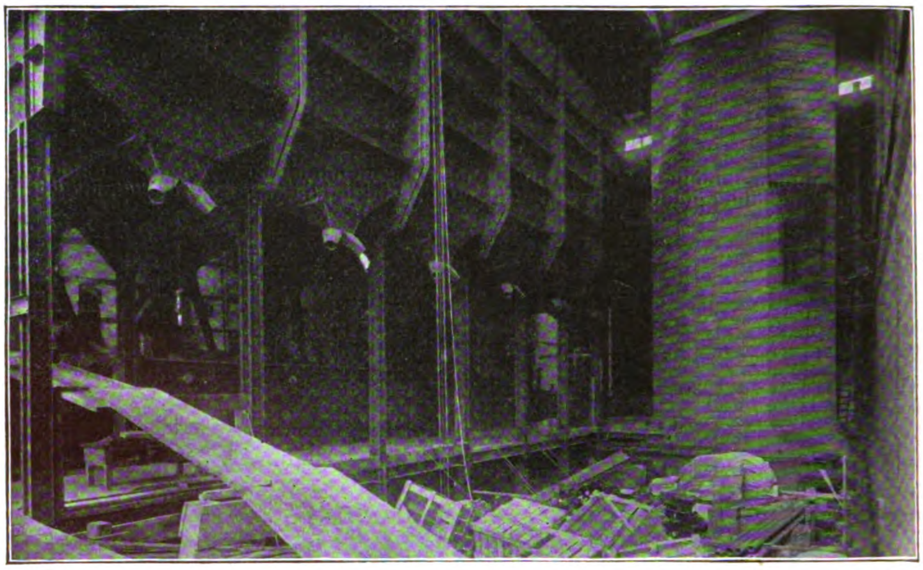


FIG. 4.—VIEW SHOWING COAL BINS AND THE BASE OF ONE CHIMNEY.

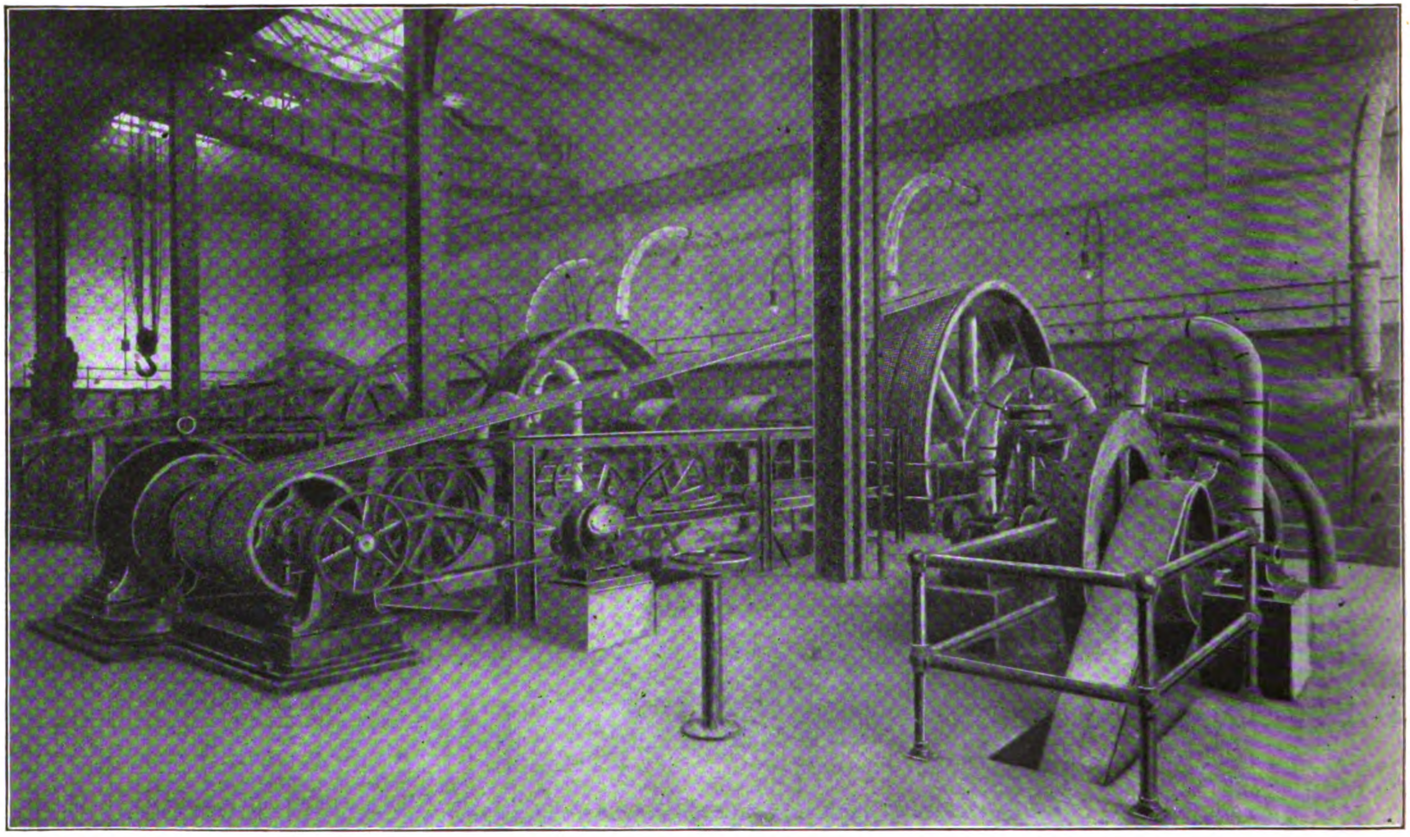


FIG. 5.—ANOTHER VIEW OF ENGINE ROOM, SHOWING ROPE-DRIVE.

used to operate the furnaces, which are capable of working the boilers considerably above rated output, even with ordinary Illinois coal. Hopper-type ash-pits are used, with gates which permit dropping the whole contents of the hopper into a steel car under them. A 3-foot gauge railway track is laid to allow the car to reach all of the ash-pits easily, and when filled to be pushed to the south end of the building. Here the ashes are dumped into an elevator boot and delivered into a bin of 80 tons capacity, from which either cars or wagons can be loaded.

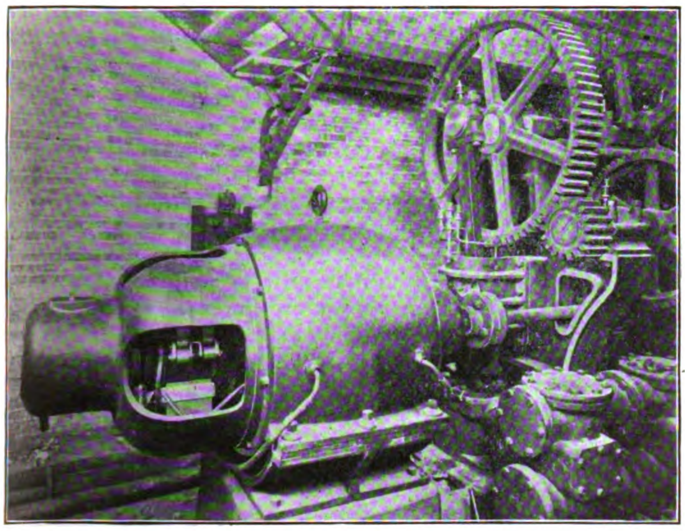


FIG. 6.—MOTOR GEARED TO TRIPLEX PUMP.

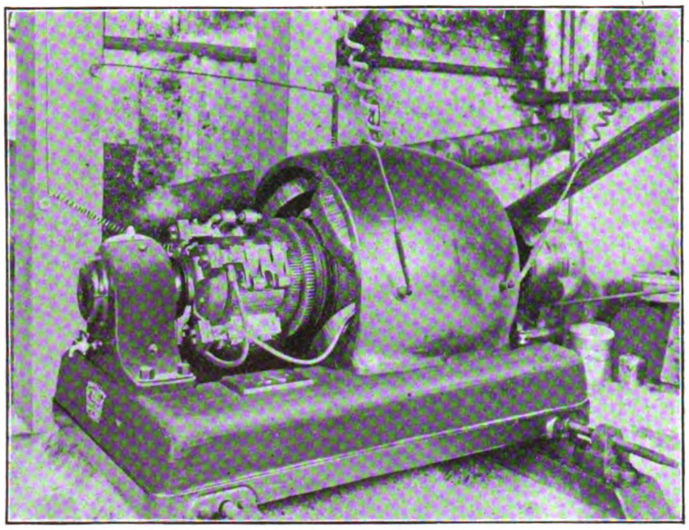


FIG. 7.—MOTOR BELTED TO HASHING MACHINERY.

The engines are all of the Corliss compound condensing type, and of varied makes because of the demand as to time of delivery; the larger engine was made by the Bass Foundry & Machine Company, of Ft. Wayne, Ind. The high-pressure cylinder is 32 inches in diameter; the low-pressure 62 inches; stroke 48 inches; speed 85 r.p.m.; it is guaranteed to show a duty of 14½ pounds of steam per i.h.p. per hour and to regulate within ½ per cent. This engine drives a direct-connected direct-current Walker generator of 850 kw. capacity, and also drives, by ropes, a 350-kw. single-phase alternator, built by the Warren Electric Manufacturing Company, Sandusky, Ohio.

There are two Filer & Stowell compound engines, having 24-inch high-pressure cylinders, 46-inch low-pressure and 48-inch stroke, running at 90 r.p.m.; guaranteed to produce an i.h.p. on 14½ pounds of steam an hour and to regulate within 1½ per cent. Each of these engines is direct-connected to a 500-kw. direct-current Westinghouse generator of latest railway dsign, and also drives a 180-kw. single-phase Warren alternator, by ropes. A steel frame between alternator and engine, as shown in Fig. 5, provides a track for the travel of the tension carriages.

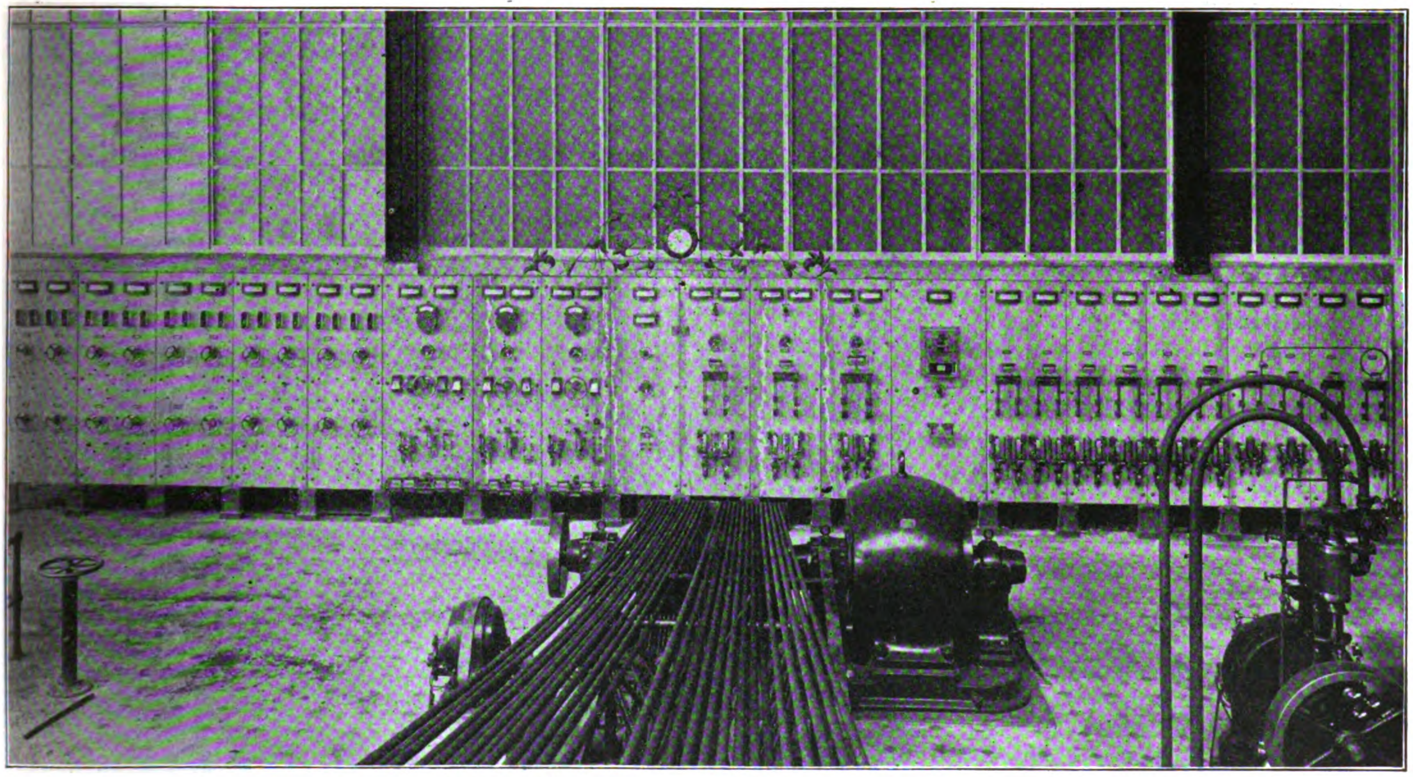


FIG. 8.—VIEW OF THE SWITCHBOARD, INCLUDING PART OF ONE OF THE ROPE-DRIVES.

The switchboard, shown in Fig. 8, is 44 feet long and 8 feet high, made of gray Vermont marble 2½ inches thick, and contains 18 panels. The board provides control for an alternating-current system of 710 kw. at 1100 volts for general incandescent lighting, and a direct-current 550-volt system of 1850-kw. output for the operation of power motors. The first panel from the center, toward the left, is the engine-driven exciter panel; the engine-driven exciter is installed as a reserve. The next three panels to the left are for the control of the three alternators; each panel is provided, in addition to the usual equipment, with a Chapman voltage regulator. The five remaining panels to the left are the feeder panels, each provided with equipment for two feeders.

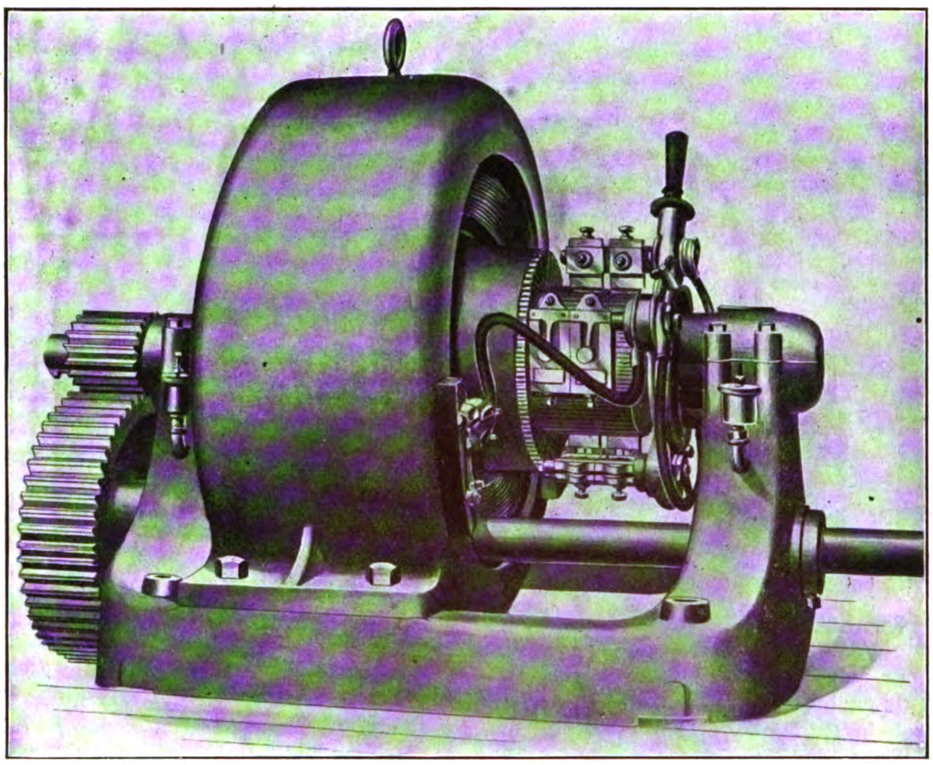


FIG 9.—ONE OF THE SPECIAL GEARED MOTORS

The first three panels to the right of the clock are the direct-current generator panels; the next is a totalizing panel, and has mounted on it one 4000-ampere 550-volt Thomson integrating wattmeter; one 4000-ampere ammeter with shunt, and one bracket for a portable voltmeter. The remaining five panels on the right are the feeder panels for the motor circuits. The only unusual feature about the board is the location of the circuit-breakers, which are all at the bottom of the panel; the engineers who designed the board considering it handier to close the breakers by lifting than by pushing. The switchboard was built by Julius Andrae & Sons Company. The switches used on the board were built by the Crouse-Hinds Electric Company; the circuit breakers are of Ward Leonard make, and Wirt rheostats are used.

There are distributed throughout the establishment 111 motors of several makes, principally Crocker-Wheeler and Card. These motors range in power from 1½ to 200 h.p., and aggregate 3600 h.p.; comparatively few of them drive individual machines. There are a great many small machines used in the manufacturing departments and as far as possible these have been concentrated and arranged in groups, one motor being used for each working floor wherever practicable. The elevators, large fans for drying purposes, and isolated pumps are driven by individual motors. The motor equipment includes two 50-h. p., two 35-h. p., twenty-three 25-h. p., and fourteen 15-h. p. Crocker-Wheeler motors; most of these being geared machines, as shown by Fig. 9. The remainder of the motors are Card and T.-H. Fig. 6 shows a Card motor geared to a large triplex pump, and Fig. 7 gives a view of another Card machine, which is belted to a line shaft from which are driven hashing machines and a bank of friction elevators.

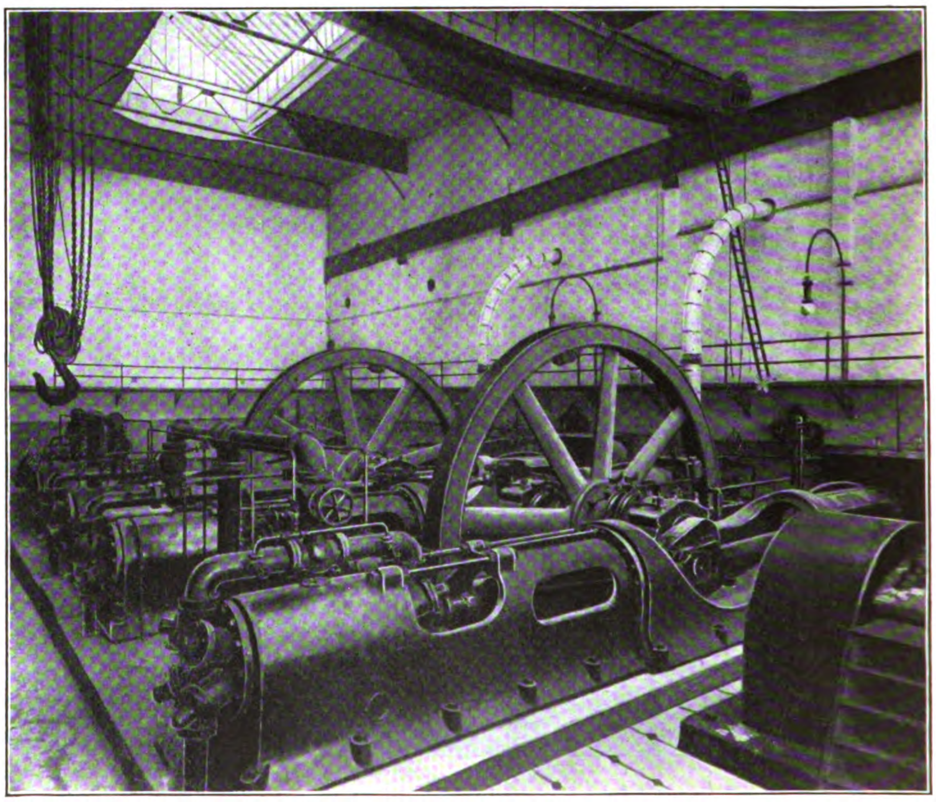


FIG. 10.—REFRIGERATING MACHINERY; ARMOUR PLANT.

The plant, as designed, contemplates the use of 22 boilers, but for the present requirements 12 were purchased; these are the Wickes vertical water-tube type, manufactured by Wickes Brothers, of Saginaw, Mich. The boilers are located on the west side of the boiler-room, as indicated in Fig. 2, in two batteries of six each, and each boiler is of 375 h. p. capacity. The floor space occupied by each battery is 68 feet 9 inches long and 22 feet wide to the front of the furnaces, so that for each foot in length there is 40 h. p. of boilers. As these boilers are practically new on the market, a description will not be out of place here. The boiler proper consists of a mud drum and a steam drum, both vertical, joined together by straight tubes, and secured by means of four heavy lugs to a circular foundation, the whole boiler being enclosed in brick-work, as outlined in Figs. 2 and 11. The steam and mud drums are of the same diameter, and the steam drum is sufficiently long to give a distance of 6 feet from water level to the steam outlet when the boiler is in operation. When erected, the boiler tubes are divided into two equal compartments by means of a heavy rabbeted fire-brick tile, passing across the diameter of the mud drum and resting upon it, and extending up to within 60 inches of the steam drum.

The tubes fore and aft, as well as crosswise, are arranged in parallel rows; the manufacturers term the forward tubes the "risers" and the after tubes the "downcomers," since the mingled water and steam rise in the forward tubes and the water descends in the after tubes. The heat leaving the furnace, which is of the oven type and extended in front of the boiler, moves upward among the risers until it reaches the top of the forward compartment; it then passes over and descends among the "down-comers," leaving the boiler at the extreme bottom of the after-compartment tubes.

Inside the steam drum, a baffle-plate extends nearly over the riser tubes at a point level with the water line; the function of this baffle-plate is to deflect the combined water and steam toward the "down-comers," as well as to prevent the splashing and spraying of water into the steam space of the boiler. In the convex head of the steam drum are four large manholes, and in the shell of the mud drum there is one; this arrangement provides a convenient means of removing, if necessary, any tubes from the boiler.

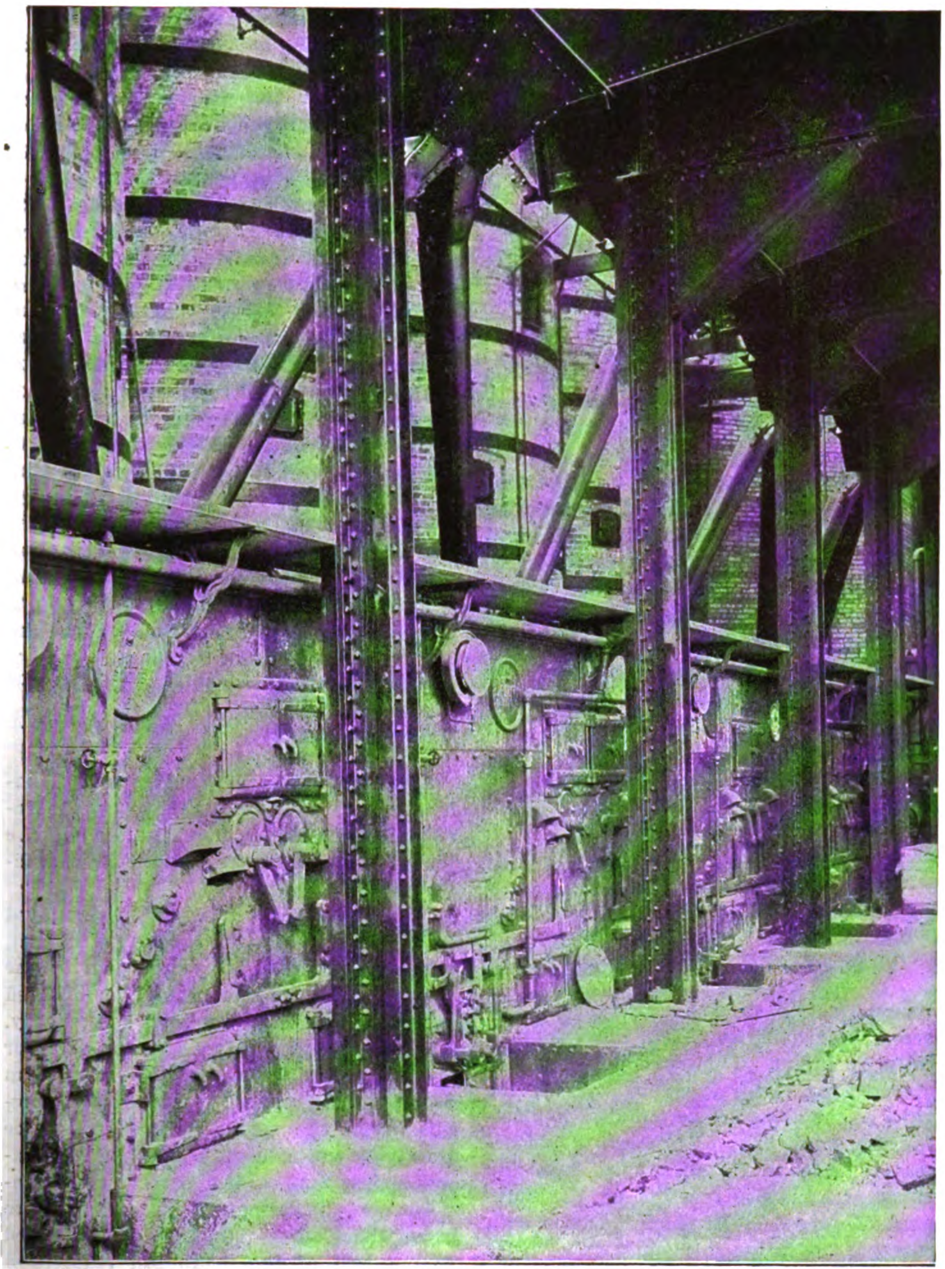


FIG. 11.—VIEW OF PART OF THE BOILER ROOM.

Feed-water enters the boiler in the steam drum close to the tube-sheet and directly over the "down-comer" tubes. The setting of the boiler is of brick, so arranged that it is entirely independent of the boiler. The main smoke flues or breechings are of brick, supported by a steel framework; the uptakes from the boilers and connection to the stack are of sheet steel. There are two brick stacks, each 12 feet inside diameter and 225 feet high above the boiler-room floor. They are octagon shape to the roof and round above; the outside shell is composed of a series of pilasters, as shown in Fig. 4, to give great strength with a minimum amount of brick; the inner core has a straight bore and extends to the top, which is covered by a terra cotta coping.

The stacks stand 50 feet from center to center, and each is placed between two batteries of boilers to reduce to minimum the length of horizontal flue necessary to carry the gases to the stacks. Their foundations are 37 feet square and 14 feet deep, with four layers of steel beams; the building walls have no connection with the stack foundations, being carried on heavy steel girders supported by independent foundations.

The boiler-feed pumps are the Knowles outside-packed plunger type. The heater is an open one of original design. The triplex pumps at the north end of the boiler-room, Fig. 2, were made by the Knowles Company; these pumps are direct-connected to electric motors, and are to be used for circulating the condensing water between the reservoirs and the cooling tower. It is the intention of the company to install on the opposite side of the boiler-room a large pumping engine for fire purposes. The pumps used in connection with the Weiss condenser are the Bibus rotary type usually furnished with this make of condenser.

The main steam header is supported on roller bearings, with rolls placed both parallel and laterally with respect to the pipe, in order to allow easy motion due to expansion or contraction. These bearings are carried on I-beams fastened at one end to building girders, the other ends resting on the boiler walls and stacks. The pipe connections from each boiler to the header are wrought-iron pipe bends, with gate valves located at both boiler outlet and header inlet; the line is securely anchored at the center of each battery and at the stack, the ends being left free to respond to expansion; the middle sections are provided with large U-bends for the same purpose. There are two valves so placed in the main line as to permit any four boilers of the two batteries to be cut out of service without affecting the operation of the plant.

The connections from the header to the engines are long wrought-iron sweep bends. All steam pipe is extra strong, valves and fittings extra heavy, and flanges are of steel; and larger valves are provided with by-passes. The steam-piping material, including the steam and water valves, was furnished by the Crane Company, of Chicago, and the pipe was erected by Armour employees. The entire steam-pipe system is connected with a Holly gravity return system, which carries all condensation and entrainment back to the boilers. The insulation used is laminated sponge felt 2 inches thick, supplied by the Manville Covering Company.

The refrigerating machinery, a view of which is given in Fig. 10, is of Linde type, made by the Fred W. Wolf Company, of Chicago. The two machines shown in the cut are now in operation, and provisions are being made to install two more, as shown in Fig. 2. These machines are operated by Corliss compound condensing engines, having 26-in. high-pressure cylinders, 48-in. low-pressure and 48-in. stroke; the ammonia cylinders are 21 ins. in diameter and 48 ins. stroke. At 50 r. p. m. these machines will give a duty of 450 tons of ice daily; the two new machines will each have a capacity of 600 tons, making a total daily capacity of 2100 tons, which is largest in the world. The Wolf Company also furnished the pipe and fittings used for the ammonia work throughout the plant.

During the past year, 500,000 feet of 2-in. expansion pipe has been installed, and every fitting, valve and flange have been sweated and tested before being put in place. The coils are, in nearly every case, placed in a bunker provided for the purpose; they are suspended from the floor above by hangers made of bar iron and hooks, the object being to get them near the ceiling in order to permit the use of a composition paper roofing on the decks.

Connections are provided which allow any individual coil in the entire system to be pumped out and repaired without interfering with any other part of the system; this is done by running an independent suction and connecting into an opening left in each coil. In the engine room is a small six-ton vertical refrigerating machine. This machine is connected with the auxiliary suction referred to, as well as to the pump-out connection from the ammonia condenser; this makes it possible to pump out any part of the entire system, or to charge the system without the use of the large machines. This is an entirely new feature, made necessary by the exclusive use of such large units, and its utility is apparent.

The use of compressed air has gradually developed in the packing business until it has become regarded as one of the essentials. It is used for running small air motors in cold-storage rooms where electric motors are not suitable; for agitating oils and lard during the processing; for mixing the brine in the pickling department; in combination with gas for branding purposes; for operating hoists and engines used in opening and closing scrapers and in the pumping of artesian wells. To meet the demand for air, one 30 in. x 60 in. and one 20 in. x 48 in. Rand air compressors are connected tandem with Corliss steam engines of same dimensions. These engines are two that were displaced by the new installation; the connections between the air compressors and engines were made by Armour engineers under the supervision of the writer.

This, like all such undertakings, was at one time the single thought of an individual; that individual is the writer, and the thought is now nearly seven years old. Valuable assistance was rendered in the work by Messrs. C. F. Hall and Watson Hurlburt, two engineers of ability; Mr. Hall had charge of the drafting room while the drawings were being made, but left soon after; Mr. Hurlburt remained until the plant was completed, following it through in every detail. Messrs. Pierce & Richardson, electrical engineers, looked after the electrical equipment; they designed and wrote the specifications for the switchboard and transformers. Mr. James Malia, the company's electrician, looked after all outside wiring and connections.

The Regulation of Variable Speed Motors.

RHEOSTAT, DOUBLE COMMUTATOR AND MULTI-VOLTAGE CONTROL.

BY ALTON D. ADAMS.

The matter of adaptation of motor speed regulation to any particular case, is slightly complicated by the fact that there are several methods of regulating electric motor speeds, each of which varies in its effect on efficiency and first cost, and also by the further fact that a means of speed regulation eminently suited to one class of work is of little value in another. Where electric motors are to be applied to work that requires a variable speed, the range of the necessary speed variations and the number of intermediate speeds should first be learned. Next, the rate at which work must be done or energy expended, at the speeds desired, should be determined, in other words, the relation between work and speed variation found. Knowing the extreme limits between which the speed must vary and the size of the steps by which the variations may be made, it is possible to select a method of speed regulation to accomplish the desired results at the smallest first cost of equipment and the highest subsequent efficiency of operation.

Probably the oldest and certainly the most generally used means of motor speed regulation is a variable resistance in the armature circuit, as shown diagrammatically by Fig. 1. This variable resistance changes the motor speed by varying the volts at the armature terminals. Neglecting the small drop of pressure in an armature, due to its resistance, also the effect of armature reaction on the magnets, the speed of an electric motor with constant excitation in magnet coils varies with the e. m. f. at the armature terminals. Assuming a constant pressure for the current supply, the necessary variations of this e. m. f. are attained by such a drop of pressure in the rheostat for each speed, that the sum of volts between the rheostat terminals plus the volts between armature terminals, equals the line pressure. The same current is constantly flowing in the motor armature and in that portion of the rheostat then in use, so that, when this current is the rated current of the motor, its output drops from the maximum nearly as do the volts at the armature terminals. The maximum armature current, with magnets of uniform strength, corresponds to constant torque for all speeds, and, as work is measured by the product of pull and speed, the rheostat method of control allows the motor output to vary directly with its speed.

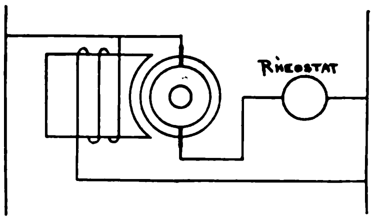


FIG. 1 —ORDINARY RHEOSTAT CONTROL.

As the maximum ampere capacity of a motor armature is fixed by its structure and the sectional area of its windings, it is evident that the maximum absorption of electric energy by an armature must vary with the volts at armature terminals. If the load, on which a motor with a rheostat in the armature circuit is to work, requires a constant turning effort, and, therefore, constant armature current for all speeds, the rheostat wire or conductor should be of uniform section throughout its length. The total resistance of the rheostat, where the maximum armature current is required at all speeds should be sufficient to cause a drop in the supply pressure in direct proportion to the reduction of speed wanted, neglecting the small armature resistance. Thus, if a motor that takes 40 amperes at 220 volts for its armature at its greatest load and speed is to be reduced in speed one half, with constant torque, the necessary resistance in the rheostat is found from the formula $\frac{\text{Volts}}{\text{Amperes}} = \text{Ohms}$; therefore the resistance in this case must be $110 \div 40 = 2.75$.

There should be at least as many connections, at equal intervals along the resistance, through contact points on the rheostat, as there are desired intermediate speeds.

If the motor speed is to be regulated by a rheostat in the armature circuit, when the amperes and consequent torque are less than the maximum, the included resistance must be increased accordingly. The amount of resistance where a motor driving a small part of its maximum load must be reduced to one-half or one-quarter of the maximum speed, may be relatively quite large. Thus, in the example just figured, if a current of 10 amperes in the armature is sufficient to move the load, a reduction of the speed to one-half of the maximum requires a resistance in the armature circuit of $\frac{110}{10} = 11$ ohms. If rheostat regulation is to be provided for large reductions of motor speed, not only with full load current, but also with a much smaller number of amperes in the armature and rheostat, it may be found that to give all of the resistance carrying capacity for the maximum armature current is not necessary and involves too much expense in the rheostat. In this case a separate rheostat may be provided for each class of work or the resistances for different loads may be separately mounted in the same rheostat. So far as the range of speed variation and the sizes of steps by which the changes occur are concerned, the results attainable with a rheostat in the armature circuit are all that could be desired. Here, however, the advantages of rheostat control are at an end.

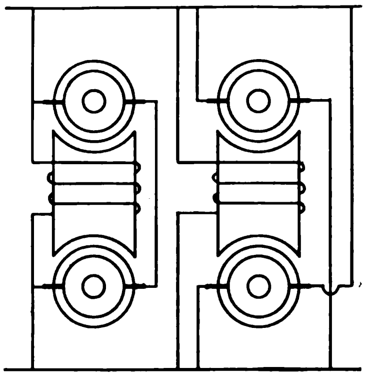
As already seen, the working capacity of a motor with resistance in the armature circuit decreases merely as the speed, and this unfits the combination for many cases where speed regulation is necessary. The net efficiency of a motor and its regulating devices is, of course, the ratio of the electric energy drawn from the supply line to the mechanical work delivered by the motor. Watts expended in the rheostat obviously represent a total loss as useless heat. Consider again the case of a motor operating at full speed and load with an armature current of 40 amperes at 220 volts. Assuming that 8 volts are necessary to force the armature current through the resistance of this armature, the counter e. m. f. of the armature at full speed is 220 — 8 = 212 volts.

If the motor speed is now reduced one-half on a load that requires constant torque so that the current of 40 amperes continues to flow, the counter e. m. f. must be reduced to one-half, or to 106 volts. The regulating rheostat must, therefore, have a drop in pressure between its terminals of 220 — 8 — 106 = 106 volts, and the watts expended in it are 40 × 106 = 4240. Allowing 1.2 amperes for the shunt winding of this motor, the total watts taken from the supply circuit are (40 + 1.2) 220 = 9064, and the portion of the total energy expended as heat in the rheostat is 46.7 per cent. The watts actually entering the motor, when it operates at full torque and one-half of the maximum speed are, therefore, only 53.2 per cent. of the power taken from the supply line.

With constant armature current and magnet excitation the efficiency of a shunt motor is nearly independent of its speed, only a small change taking place in the friction and hysteresis losses. The motor just considered, of about 9 kw. capacity should have an efficiency at full load and speed of about 85 per cent., corresponding to an internal loss of 15 per cent. of the full load energy as heat. On one-half speed, with the maximum armature current, the internal motor losses may drop to 13 per cent. of the energy drawn from the supply line at full load and speed. As the rheostat was found to consume 46.7 per cent. of the entire amount of energy taken from the line at full armature current, the portion of total work lost one-half the full motor speed is 46.7 + 13 = 59.7 per cent. The efficiency of the rheostat and motor combined with maximum armature current and one-half of the full speed is, therefore, 40.3 per cent.

As lower speeds are reached the watts consumed in the rheostat grow large and the efficiency of the combination goes still lower. Where the amperes required at reduced speeds are less than the full armature capacity, the percentage of the total energy drawn from the line that is wasted in the rheostat increases very slightly over that with maximum current, but as internal motor losses do not decrease directly with the torque and speed, the combined efficiency is lower.

The speed of a motor may be regulated to some extent by means of two or more independent armature windings, on one core, each winding having its own commutator, as shown by Figs. 2 and 3. In practice the number of distinct windings on the same armature is limited to two, as the complication of connections to commutators becomes undesirable where there are more than two. Any desired relation may exist between the capacities of the two armature windings, but the most common method is to make the windings duplicates of each other, so that they may be worked at full capacity in either series or multiple. Each armature winding is ordinarily proportioned for connection to the supply mains alone or in multiple with the other, when the motor is to operate at its highest speed. With duplicate armature windings, a motor has its greatest capacity when these windings are connected to the source of current in multiple, as in Fig. 3, and the speed is at the maximum. When a lower speed is desired the armature windings may be connected in series with each other across the line as in Fig. 2. This series connection will give one-half of the speed that was had with the windings in multiple, provided they are exactly alike, and other factors remain the same. Double armature windings that are duplicates of each other provide, therefore, for only two speeds, one of which is twice the other.


FIGS. 2 AND 3.—DOUBLE COMMUTATOR CONTROL.

If the ability to operate the two armature windings in multiple and thereby secure their combined capacity at any one time, is not essential, and three speeds are desired, the two windings may each be given the same ampere capacity, but proportioned for different speeds when supplied at the same pressure. Other factors remaining constant, the speed of any armature varies inversely as the number of wires in series with each other, in operation per pole, and this fact enables the third speed for a motor to be at once calculated, when the speed for each of its two armature windings, considered separately, is known. For illustration take the case of a motor with two independent armature windings and commutators, one of these windings giving the motor a speed of 1500 revolutions and the other winding a speed of 1000 revolutions a minute, when connected alone to a supply of constant potential. Let it now be required to find the speed at which the motor will operate when the two windings are put in series through their commutators, and then connected to the same supply as before. Since speeds vary inversely as the number of armature wires in series, the winding that gives the motor a speed of 1000 revolutions must have a number of wires that is 1.5 times as great as the number in the winding that gives 1500 revolutions per minute.

When the two windings are connected in series, the total number of operative armature wires becomes 1 + 1.5 = 2.5 times as great as that in the winding that gives a motor speed of 1500 revolutions, so the speed for this series connection will be 1500 ÷ 2.5 = 600 revolutions a minute. Two windings on a single armature core, unequal as to the number of wires contained, should not be connected to the supply line in multiple, as the winding with fewer turns will take and the other deliver current to the mains.

A motor with duplicate armature windings has its greatest capacity and speed when the windings are used in multiple, as the speed is then that for either winding alone, while the amperes taken and the corresponding motor work is that of both windings combined. When the two duplicate windings are connected in series and then to the supply line, the motor speed is reduced to one-half of that for either winding and the working capacity is approximately one-half of the maximum ability of the armature, because the current is limited to the capacity of one winding, and the energy taken from the line is only one-half as great as when the two armature windings are in multiple.

A motor with two armature windings, unequal as to the number of wires, but of the same capacity, can work at the same rate whether one of the windings is used alone or they are both connected in series. This rate of work is obviously only one-half of that which might be obtained from the same motor with duplicate armature windings. The reason for this uniform working rate for either winding alone or both in series, where the ampere capacity is the same for each winding, appears readily from the fact that the maximum energy taken from the supply line for each case is the same.

Where provision need be made for only two speeds and the power necessary at one of these speeds is much smaller than the power at the other it may be desirable to give the windings different ampere capacities. If this is done the two windings cannot be operated simultaneously, but a lower speed can be attained with one of the windings than would be possible if its ampere capacity were made equal to that of the other winding for the higher speed. In fact, these windings of unequal ampere and working capacity permit the speed of a motor to be reduced to almost any desired extent below its maximum, provided the rate of work may be reduced in more than like proportion.

To illustrate the application of such windings, take a case where the motor must deliver 10 h. p. at 1200 r. p. m. during a part of the time and must operate at other times at a speed of only 300 revolutions, the rate of work for this low speed being only one h. p. If it were necessary to give each armature winding the same ampere and working capacity, a much larger and more expensive motor would be necessary to meet the conditions of speed variation than is required for the combined reduction of both speed and load, as indicated.

Results as to efficiency with double-wound armatures are nearly equal to the best obtainable with other methods of regulation, since all necessary losses are those internal to the motors. As the losses in motors vary but little in the range of ordinary speeds, the efficiency of motors, whose capacities are proportional to their speeds, must be lower at the low than the higher rates of revolution. This point is clear when it is held in mind that efficiency is the ratio between the energy absorbed from the line and the work done, and may, therefore, change though the loss of energy remain constant.

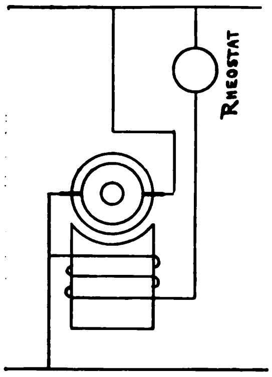


FIG. 4.—FIELD VARIATION.

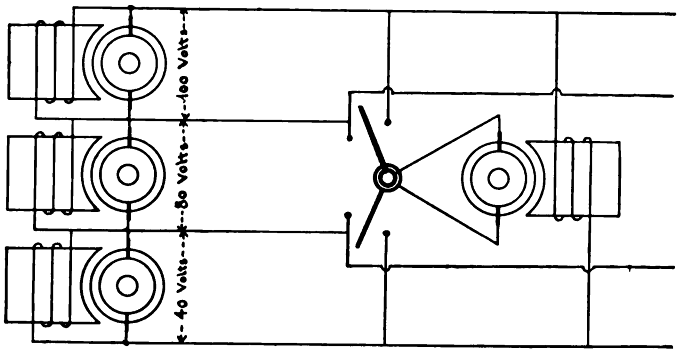


FIG. 5.—MULTI-VOLTAGE CONTROL.

One of the factors that effects directly the speed of an electric motor is the strength of its magnets, or the magnetic flux through its armature. Other conditions remaining constant, the speed of revolution for a motor armature changes inversely as does the amount of magnetic flux passing through it. The speed may, therefore, be regulated by suitable variation of the magnetic strength. The strength of magnets is usually affected by changes in the magnetizing forces exerted by the magnet coils, but may be done by altering the resistance of the magnetic circuit.

The magnetizing force of field coils may be changed by altering their resistance, connections or the energy expended in them. With a shunt motor, which is by far the most generally used for stationary purposes, if the speed is to be regulated by means of its magnets, a rheostat is commonly connected in series with the shunt winding, as in Fig. 4, so as to lower the pressure at its terminals, and consequently the amperes and ampere turns of magnetizing force in it. A similar result may be obtained in this case by a shunt winding that is divided into sections, which are cut in or out of action as are differently grouped to produce any desired speed.

Where it is desired to effect speed changes by altering the reluctance of the magnetic circuit, parts of the magnets are in some cases so moved as to vary the air-gap between the pole-pieces and the armature core, while in others the area of the air-gap space may be increased or decreased. As it is usually much easier to alter the electrical connections of the magnet coils than to shift the relative positions of the parts of the magnet frame, the methods that work with the exciting coils are usually preferred. As only one set of armature coils, which remain constant, is used in this method of regulation, and as there is no external resistance in the armature circuit, the motor capacity remains constant for all speeds.

The lowest rate of speed attainable with a given motor is that at which the magnets are at their maximum strength; that is, causing the greatest magnetic flux through the armature core. The highest speed practicable, with full-rated current in the armature, is that at which the magnets are barely able to counteract the armature reaction sufficiently to prevent the sparking at the commutator from becoming objectionable.

If an ordinary motor be selected, the speed of which corresponds to the lowest one desired for any particular case, it will be found, when an attempt is made to increase the speed by weakening the magnets, with the full-load current in the armature, that the speed can be raised by only a small per cent. before bad sparking at the commutator begins. The fact is that motors must have special proportions, when their speeds are to be regulated by changes in the magnetic field during full-load operation. When this is done, a large range of speed variation may be had by means of regulating the magnet strength. The main objection to this method of speed regulation comes in the matter of the first cost of the machine, which increases with the range of speed, and may be twice that of an ordinary motor which runs at the lowest speed desired.

Changes in speed between the extreme limits are easily made as small as may be desired by a suitable number of connections on the rheostat or the magnet windings.

Since the capacity of a motor regulated by changes in the magnet strength remains constant for all speeds within the sparking limits, the efficiency is higher at low speeds than that obtainable with any other method of speed regulation. The only loss external to the motor in this method is the small one in the field rheostat, and this loss disappears at the lowest speed when the rheostat is out of use. While the efficiency of a motor with such speed regulation is nearly constant so long as the load is uniform, yet the increased friction and hysteresis losses may lower it a little at the higher speeds. It should be noted, however, that the loss in the magnet coils of a motor, including that of the rheostat, are less at high than at low speeds, because of the smaller amount of energy they take from the line. In many ways this is an ideal method of speed regulation.

The speed of a motor can be varied by changes in the pressure of the supply mains to which the armatures are connected, as above noted. This pressure may be varied in any one of several ways. One plan is to use three dynamos of different voltages, connected up to multiple circuit wires, as indicated by Fig. 5. The voltages of the dynamos are determined by the range and relation of the speeds desired at the motors. Any motor may then be operated under any of the available pressures, at the corresponding speed, or any two, or all three of the supply pressures may be combined to give the desired speeds at any of the motors.

Assume, for illustration, that the three dynamos used give voltages of 40, 80 and 100 respectively. By the aid of combinations, seven pressures of supply are now available at motors, namely, 40, 80, 100, 120, 140, 180 and 220 volts. These seven voltages permit motors which give their maximum speeds at 220 volts to be reduced in speed through six steps down to less than one-fifth of the highest rate of speed. Shunt motors regulated by this and similar plans usually have only their armatures connected to the different voltages, the magnet coils being supplied constantly at some one of the available pressures. In another system for the supply of energy to electric motors at variable voltages, each motor is supplied by a separate dynamo, usually driven at a constant speed, and the e.m.f. delivered by this dynamo is varied to meet the requirements of motor speed. The variations in the dynamo voltage are produced by changes in the exciting power of its shunt winding.

The similarity between the method of speed regulation by means of a rheostat in the armature circuit and that which reduces the pressure of the electric supply may here be noted. In each case the voltage at the terminals of the motor armature is varied to produce the required changes of speed. Where the dynamo voltage is varied, the losses are much less than when a rheostat in the armature circuit is employed. When each motor is supplied by an independent dynamo, any desired gradation of speeds can be obtained by changing the strength of the dynamo magnets.

In those systems where several sources of current supply at different voltages are employed, the number of speeds obtainable are not all that are desired for some kinds of work. The capacity of a motor operating under variable voltage at the armature terminals is greatest when the voltage and its corresponding motor speed are at the maximum; and decreases directly with the operating pressure. This decrease of capacity with speed is obvious from the fact that while the ampere capacities of the motor armatures remain constant, the voltage, and therefore the watts, drop with the speed. The losses in the motors alone under this system of speed control vary but little, and the efficiency is high where the voltages at the armature terminals are obtained from a supply system of several distinct pressures. Where an additional motor and dynamo intervene between a source of constant pressure supply and the variable-speed motor, however, the combined losses in these three machines materially reduce the net efficiency. At low stages of speed the motor efficiency suffers, because the losses remain nearly constant, while the work done is reduced to, perhaps, one-quarter of the maximum capacity.

Reverting to the three main classes of work previously named, the means of motor speed regulation best suited to each may be considered. Starting with what is, perhaps, the most general class of work, that in which the power varies directly with the speed, the method of motor regulation with double-wound armatures of constant ampere capacity is well suited to those cases where only two or three different speeds are wanted. If a number of intermediate speeds are also desired, the method of changes in the magnet strength may well be combined with that of the double-wound armatures; the range to be covered by magnet changes being small, this method will not add greatly to the cost of the motors. Where service must be taken from the constant pressure supply, the expense of additional motors and dynamos to furnish a variable voltage at the regulated motors, will in many instances be a bar to this method of speed regulation. In isolated power plants for manufacturing purposes, the plan with two, three or four dynamos of different voltages seems desirable. To this may well be added the method of variable magnets, to provide for all intermediate speeds. Lastly, because least desirable, the rheostat may be used in the armature circuit either for the total speed reduction, or, better, in conjunction with the double-wound armatures having two commutators.

Considering next those classes of work in which the rate is nearly constant for all speeds, there seems to be one method of speed control eminently adapted to their requirements. The speed control that operates by changing the magnet is just what is required for a uniform rate of work at different speeds, because the changing torque between the motor armature and magnets follows every change of speed to maintain a uniform motor output. No other method of motor regulation meets the requirements for constant rate of work at all speeds, and such work can only be done by motors otherwise regulated when they have much more than the necessary capacities at the high speeds. The method of speed regulation by magnetic changes is of much value in motors for driving machine tools.

For loads, such as centrifugal and disc fans, that vary in their power requirements with the square, cube or some higher power of their speeds, the regulation by double-wound armatures is well suited. This is especially true of double-wound armatures with different ampere capacities in their two sets of coils, as a low speed may thus be obtained from a comparatively small and cheap motor. The variable magnet or the rheostat method of regulation may be combined with the above for the intermediate speeds.

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REGULATION OF VARIABLE SPEED MOTORS BY VARYING IMPRESSED AND COUNTER E. M. F'S.

L. B. MATHER.

It is obvious that rheostat control, although ideally simple of application, leaves much to be desired when individual motors are used to drive machine tools, printing presses or other variable speed apparatus. Not only is it uneconomical, but there is entailed an objectionable element of uncertainty as to the rate of rotation at very low speeds because of the variation of the drop in the rheostat due to variations in the armature-current strength.

In contrast to this is the precision and efficiency of control afforded by methods based upon the regulation of the e. m. f. impressed at the motor brushes, without the use of external resistance in the armature circuit. There are five of these methods. One is that employed in the well-known Leonard system in which an auxiliary motor-dynamo is employed to supply current to the motor armature, as indicated diagrammatically by Fig. 1.

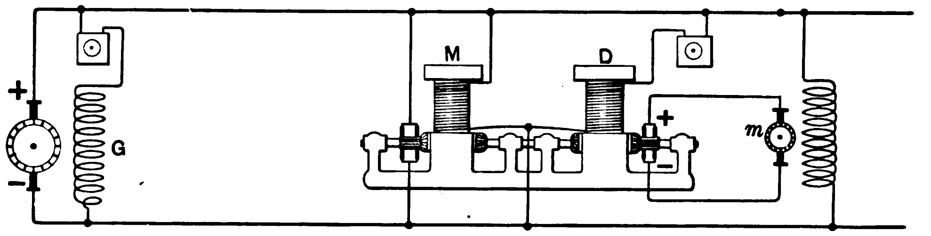

FIG. 1.—MOTOR CONTROL BY VARIATION OF THE SUPPLY E. M. F.

Here any speed can be obtained at the motor by regulating the e. m. f. of the dynamo, D. The drawback is evidently the necessity for providing a motor-dynamo for each industrial motor, m, which would be a serious outlay in a plant of many motors. The dynamo, D, must be capable of an armature output equal to the maximum demand of the industrial motor, m, and the auxiliary motor, M, must be large enough to drive its dynamo at full load, of course, so that three machines are required to do the work of one. The speed control is superb, but the first cost of the motor equipment is more than three times that of the motors used in an ordinary installation.

A disadvantage of this system is that the field-magnet of the auxiliary dynamo, D, is weakest when the current passing through its armature is greatest. This will be evident when it is remembered that at the time of starting up the industrial motor, m, the e. m. f. at its brushes must have its minimum value in order to obtain an easy start, and at the same time the armature current may be considerably greater than the full load current of the motor; in order to reduce the e. m. f. at the motor brushes to the minimum, the field strength of the auxiliary dynamo, D, must be reduced to its minimum working value.

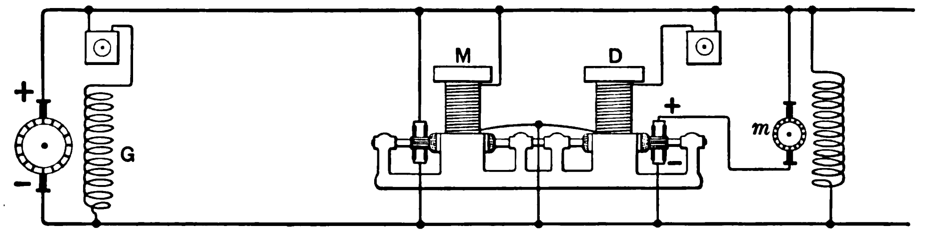

FIG. 2.—CONTROL BY OPPOSING E. M. F. OF AN AUXILIARY DYNAMO.

A kindred system is shown by Fig. 2 in which the same auxiliary motor-dynamo is employed, but the relation between it and the industrial motor, m, is different. Here the armature of the auxiliary dynamo, D, is connected in series with the armature of the industrial motor, m, and generates an e. m. f. in opposition to that impressed by the supply circuit. It is plain that when the field magnet of the auxiliary dynamo is strengthened, its e. m. f. cuts down the e. m. f. at the motor brushes and reduces the speed of the armature; and weakening the auxiliary dynamo field reduces its opposition to the line e. m. f. and the industrial motor has to speed up to make up the difference.

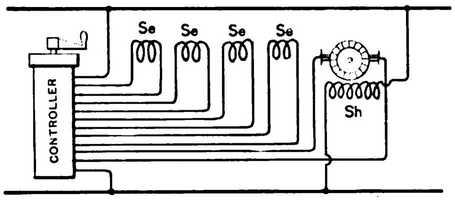

FIG. 3.—CONTROL BY FIELD VARIATION.

This confers the distinct advantage that at the moment of starting the industrial motor under load, when the current through its armature (and, therefore, through the armature of the auxiliary dynamo) is greatest, the field strength of the latter is at its maximum value. The system also possesses a slight advantage in point of first cost over the first system, because the auxiliary motor-dynamo does not need to be quite so large for a given speed.

It is obvious that equivalent results are offered by a specially designed motor of three to four times the ordinary weight and arranged for regulation by varying the strength of its field magnet, as indicated by Fig. 3. The abnormal weight is necessary in order to secure the desired margin of field variation without having the field so weak at full speed as to permit destructive sparking. For example, an ordinary 230-volt motor having an air-gap area of 100 sq. in., working normally at a density of 30,000 lines per sq. in. and running at a speed of 1200 r. p. m. would be about 380 wires around the armature circumference. A motor of equal full-load output designed for speed control by field regulation, would preferably have the same number of armature wires and an armature sufficiently longer to permit the magnetic flux to be increased, say six-fold, for minimum speed. The air-gap density might reasonably be raised to 50,000 lines for the lowest speed, so that the armature would need to be about 3.6 times the length of the armature of the ordinary motor. Then at full speed of 1200 revolutions the field strength would be exactly the same as that of the ordinary motor and there would be no sparking.

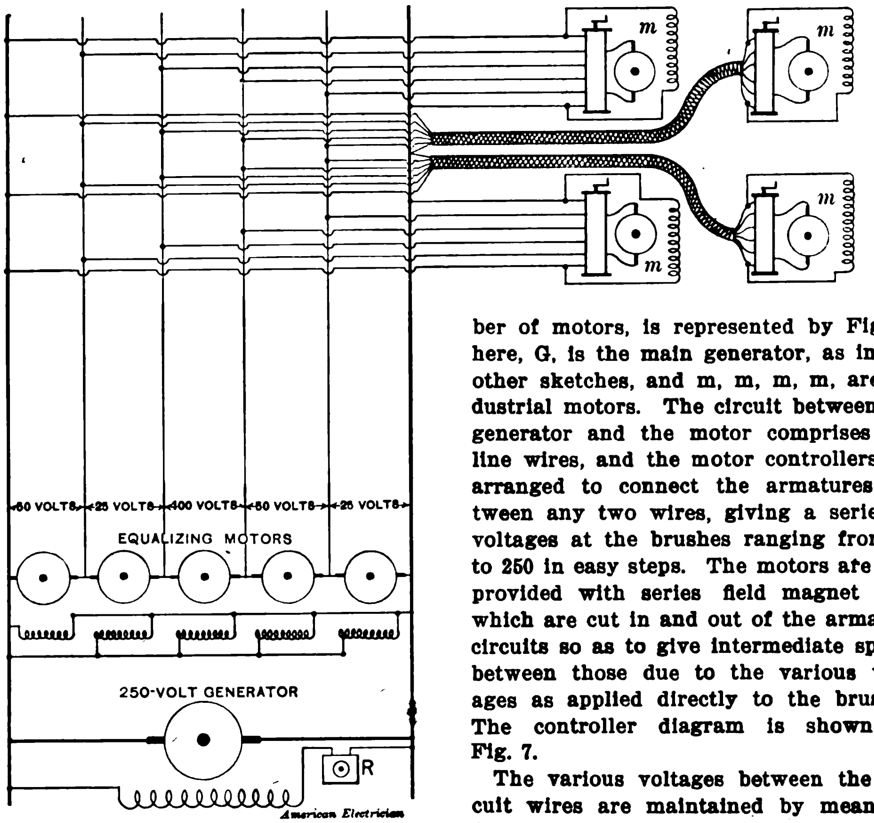

FIG. 5.—MULTI-VOLTAGE CONTROL, WITH MOTOR BALANCER.

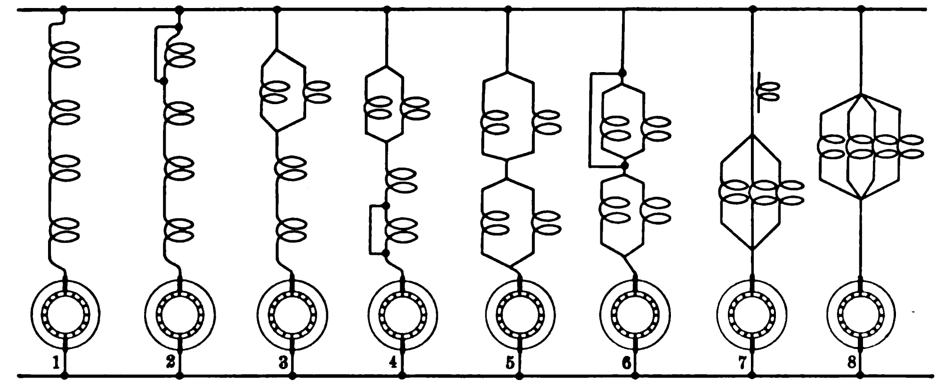

FIG. 4.—CIRCUIT COMBINATIONS OBTAINABLE BY THE SYSTEM SHOWN IN FIG. 3.

Referring to the diagram, the shunt field winding, Sh, remains constantly in circuit and supplies the proper field magnetism for operation at full speed. For all speeds below this, the series windings, Se, are commutated to give the requisite gradations of excitation, and at the same time help to control the armature speed by varying the resistance of its circuit, as indicated in Fig. 4. Such a motor would cost less to install than the combinations previously described and represented by Figs. 1 and 2, and the degree of control is practically the same, or it could readily be made so.

The foregoing plans are all based upon special construction at the motor end of the line, which, as intimated above, runs into dollars very rapidly when a plant contains many motors. A fourth method, and one in which there is only one actually "special" apparatus for any number of motors, is represented by Fig. 5; here, G, is the main generator, as in the other sketches, and m, m, m, m, are industrial motors. The circuit between the generator and the motor comprises six line wires, and the motor controllers are arranged to connect the armatures between any two wires, giving a series of voltages at the brushes ranging from 25 to 250 in easy steps. The motors are also provided with series field magnet coils which are cut in and out of the armature circuits so as to give intermediate speeds between those due to the various voltages as applied directly to the brushes. The controller diagram is shown by Fig. 7.

The various voltages between the circuit wires are maintained by means of five motors or dynamos, the shafts of which are rigidly coupled; the fields are connected straight across to the outer circuit wires. The machines are designated "equalizing motors" in the diagram. All of the armatures are capable of the same output in watts; for example, the 25-volt armature has twice the current-carrying capacity of the 50-volt armature, and so on. One of the advantages of this system, as outlined in the diagram, is that half of the motors, m, may use the 25-volt circuit, a, b, for starting and the other half the circuit, d, e, giving a better distribution of power on the circuit wires and at the "equalizing" motors than would be had if there were no duplicate voltages. The speed gradation afforded by this system is not so fine as that obtainable with any one of the three preceding it in this article, but it is sufficient for all ordinary purposes and obviously may be arranged to give any combination desired within reasonable limits.

The fifth system, shown in Fig. 6, is very similar to the one last described, the only difference being the use of storage batteries in the place of the "equalizing" motors. Its flexibility is much greater, however, as any number of voltages, up to 125 (the main generator giving 250 volts), may be obtained by running the proper number of circuit wires. Thus, one or two motors may be connected up for very fine speed graduations around the very low speeds, and bigger "jumps" higher up the scale, while the majority of the machines are provided with only a few different running speeds; in fact, a bewildering number of combinations is possible from such a system, practically the only limitation being the e. m. f. of the main generator. The diagram shows one motor wired for a comparatively large number of low speeds and a few intermediate speeds, and another wired for five distributed steps between standstill and full speed. The chief disadvantage of the system is the care and maintenance of the storage battery. The apparatus can easily be arranged so that the charging will be entirely automatic.

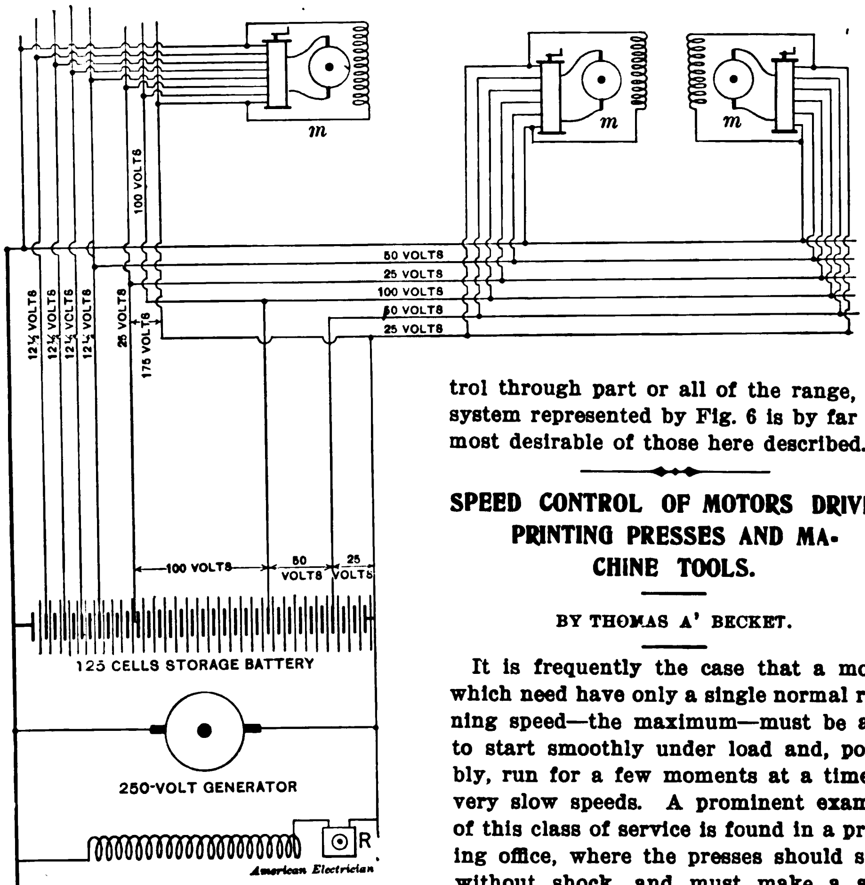
m
m
m
100 VOLTS
50 VOLTS
25 VOLTS
100 VOLTS
50 VOLTS
25 VOLTS
12½ VOLTS
12½ VOLTS
12½ VOLTS
12½ VOLTS
25 VOLTS
175 VOLTS
100 VOLTS
50 VOLTS
25 VOLTS
125 CELLS STORAGE BATTERY
250-VOLT GENERATOR
R
American Electrician

FIG. 6.—MULTI-VOLTAGE CONTROL. WITH STORAGE BATTERY BALANCER.

Summing up, it is at once apparent that where only a few motors are in use and economical operation at many speeds, with great precision of control, is required, any of the systems here described may be used advantageously, excepting that of Fig. 5; where the number of motors is large and a fine gradation of running speeds is not imperative, either Fig. 5 or Fig. 6 may be installed, and for a large plant of motors in which some or all of them must have finely graded control through part or all of the range, the system represented by Fig. 6 is by far the most desirable of those here described.

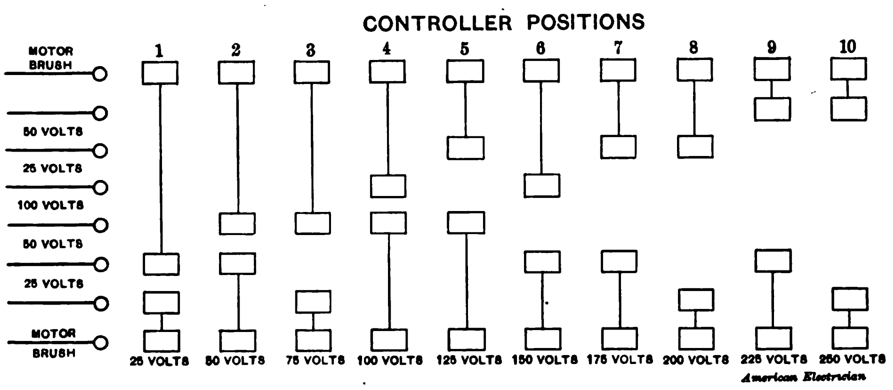
CONTROLLER POSITIONS
1
2
3
4
5
6
7
8
9
10
MOTOR BRUSH
50 VOLTS
25 VOLTS
100 VOLTS
50 VOLTS
25 VOLTS
MOTOR BRUSH
25 VOLTS
50 VOLTS
75 VOLTS
100 VOLTS
125 VOLTS
150 VOLTS
175 VOLTS
200 VOLTS
225 VOLTS
250 VOLTS
American Electrician

FIG. 7.—CONTROLLER DIAGRAM FOR FIGS. 5 AND 6.

◆

SPEED CONTROL OF MOTORS DRIVING PRINTING PRESSES AND MACHINE TOOLS.

BY THOMAS A' BECKET.

It is frequently the case that a motor which need have only a single normal running speed—the maximum—must be able to start smoothly under load and, possibly, run for a few moments at a time at very slow speeds. A prominent example of this class of service is found in a printing office, where the presses should start without shock, and must make a slow revolution or two at a time during the "making ready" of the forms. One of the most satisfactory methods of obtaining these results is represented by diagram in Fig. 1.

The controller here shown is purely diagrammatic, not constructionally typical. At the start, with the finger, F, on the first contact, and the finger, f, on the sector, s, all of the resistance coils are connected across the circuit and the armature is in shunt to the first coil, R. It is obvious that the e.m.f. at the brushes will be determined partly by the relation between the resistance of the coil, R, and that of the whole group, and partly by the amount of current necessary in the armature for starting torque. At the first moment of contact, the e.m.f. impressed at the brushes is determined by the relation between the joint resistance of the coil, R, and the armature winding, and the resistance of the whole group. For example, if the armature resistance be ½ ohm, and the resistance of R ½ ohm the joint resistance will be ¼ ohm; and if the resistance of the remaining coils be 9¾ ohms, the instantaneous e.m.f. at the brushes will be 1/40 of the circuit e.m.f. As the armature revolves, its counter e.m.f. increases the ratio of the impressed e.m.f. to the circuit e.m.f., up to a point where the current is reduced to just the amount necessary to turn the armature.

It is evident that the resistances can be so proportioned as to give any desired armature speed under a given load, for each step, and if the total resistance be comparatively small, a fine degree of control is obtainable. For best results the total resistance of all of the coils (with the armature disconnected) must be such as to pass a current considerably greater than the current required by the motor armature, and this is, of course, a disadvantage from the view-point of economy. Each successive step of the lever evidently raises the e.m.f. impressed at the armature terminals, until the finger, F, touches the segment, S; at this point the finger, F, occupies the position indicated by the arrow head, and all of the resistance is in parallel with the armature. This is not a running position, of course. Further movement of the lever

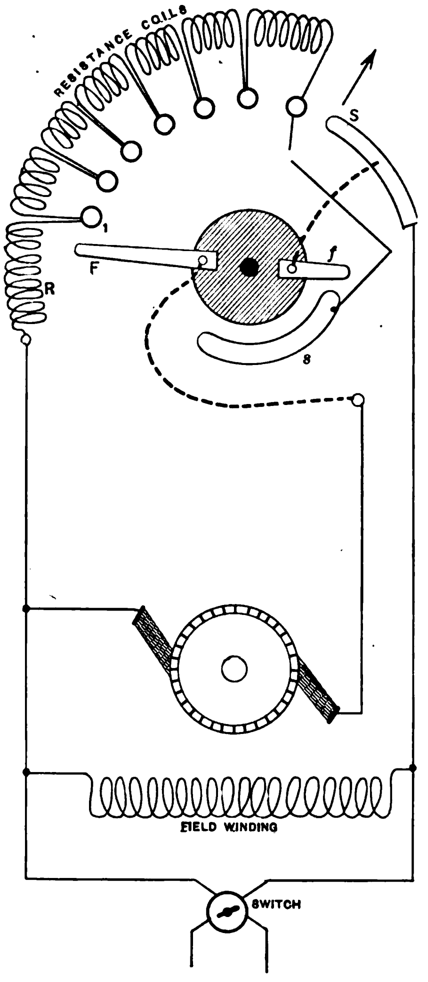
RESISTANCE COILS
S
O1
F
f
R
s
FIELD WINDING
SWITCH

FIG. 1.—SPECIAL RHEOSTATIC CONTROL.

causes the finger, f, to leave the segment, s, thus breaking the circuit through the resistance coils, and leaving the armature connected across the cupply circuit, running at maximum speed. In many cases the controller is made to disconnect the resistance, R, when the finger, F, passes to the second contact button, leaving the armature in simple senies with the resistance coils to the right of the said button.

The field winding is constantly in circuit from the time the main switch (at the bottom of the diagram) is closed until it is opened again, the controller lever affecting only the armature and resistance-coil connection. As previously intimated, the arrangement illustrated is rather uneconomical, because up to the point that the finger, F, reaches the segment, S, the current flowing is considerably greater than the full-load current of the motor. For this reason this method is hardly suitable for motors which have to run steadily for a considerable length of time at the lower speeds, but for printing presses, where the slow speeds are only used for a few moments at a time, and then the motor is run at normal speed throughout the operation of printing, the arrangement is very advantageous.

For driving machine-tools and similar service, where it is required that the motor shall have several regular running speeds, a more desirable arrangement is that shown by Fig. 2, in which speed control is accomplished by varying the strength of the field magnet. The controller lever is shown in the "off" position; it carries a number of brush fingers all electrically connected to each other and to one side of the main circuit. In the first position these fingers touch all of the segmental-contact strips, putting the armature in circuit in series with a powerful field coil and also putting in circuit all of the shunt-field coils in parallel. At the next step the series field winding is cut out, leaving the motor excited by the four shunt-field windings, and the armature connected alone across the supply circuit; at the third step one of the shunt windings is disconnected; at the fourth step another one is thrown out; and at the fifth step the third shunt winding is disconnected, leaving only one winding to excite the motor. It is obvious that in order to secure running speeds which differ very greatly from each other the motor has to be unusually heavy, but inasmuch as the normal running speeds may usually range from one-half to maximum speed, the desired speed control is possible by using a motor frame only a little heavier than the normal size and so proportioning the field windings that when all four of the shunt fields are in circuit the magnetic density in the field magnet will be very high.

This arrangement possesses an advantage over the more familiar arrangement wherein a number of series field coils are thrown in and out of circuit in order to obtain the desired changes of speed, because in that case the speed will vary widely with changes of load, at any controller position, whereas, with the present arrangement the speed of the motor will remain practically constant under any load within the capacity of the motor, at each step of the controller. This feature is frequently highly desirable, as, for example, in driving a lathe, boring mill or other machine tool, where it is preferable to have the speed unaffected by changes in the depth of cut or quality of material.

It will be obvious that a combination of these two arrangements would give an ideal method of speed control for a printing press which it may be desired to run at any one of several regular speeds not far apart, the running speed depending upon the character of the printing to be done. The resistance arrangement would be used for starting up and making ready, and the controller would also be provided with the arrangement shown in Fig. 2, the first position of which would extend throughout the entire range of the resistance variation, the second step being reached after the finger, F, Fig. 1, is on the segment, S, and the finger, f, has left the segment, s.

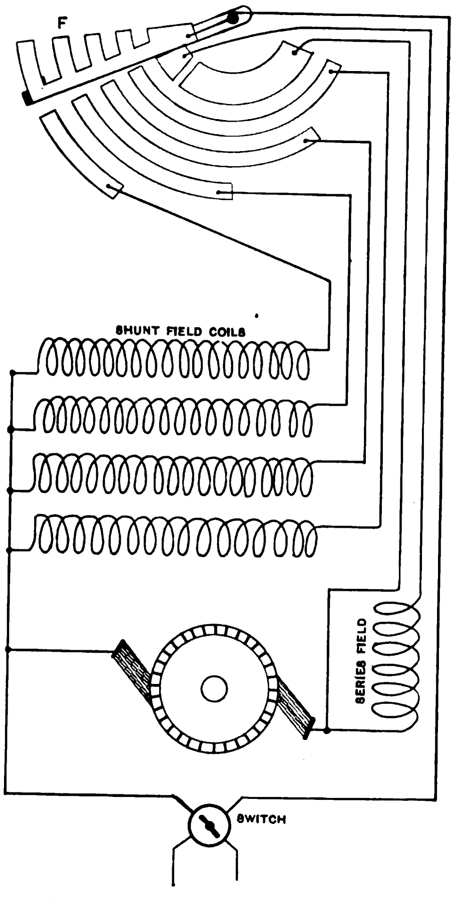

FIG. 2.—MOTOR CONTROL BY VARIATION OF FIELD MAGNET EXCITATION.

* * *

South Atlantic Cable.—Cables have been laid from Capetown, South Africa, to St. Helena, from St. Helena to Ascension Island, and from Ascension Island to St. Vincent. This gives a complete cable route to South Africa by way of Madeira and St. Vincent. The rate from London to Ascension Island and to St. Helena is 98 cents a word.

LIVE STEAM FEED-WATER HEATERS.

BY W. F. DURAND.

The purpose of a feed-water heater, no matter what the variety or mode of operation, is to enable the boiler and engine to produce more power per pound of coal burned in the furnace. If this end is not accomplished, the feed-water heater has no excuse for existence. In order to examine the question of how it may be possible for a feed-water heater to thus bring about an increase in the power developed we must first note that the steam engine and boiler together constitute in reality a means simply for transforming heat into work. It is actually heat which the engine uses and not steam. The latter is simply a carrier for the heat, and may be returned again and again to the boiler from the engine, while heat must be continually provided, and as continually disappears, a part being transformed into work and a part being allowed to escape as heat. If, therefore, the heat which thus escapes without having been transformed into work can be in any way decreased, therein lies an increase in the power per pound of coal burned, and a decrease in the cost per unit of power developed.

Without entering into any exhaustive analysis or census of heat losses, the two of chief importance are: (1) By way of the stock, carried off by the waste furnace gases; and (2) by way of steam which may escape without doing its full share of work, or without yielding up at least some part of its heat for return to the boiler. Of these various wastes, by far the greatest occurs in the main engine, and as a necessary feature of its mode of operation, while a further loss may occur in various auxiliaries, and otherwise than in the main engine.

In the present article we are concerned with the relation of the live-steam heater to these losses. It is, of course, clear that an economizer or feed-water heater placed in the uptakes of the boilers, or base of the stack, may absorb some of the waste heat of the furnace gases and thus effect a saving of heat which would otherwise have been lost. Also it is clear that if steam, instead of being exhausted to the air and thus rejected with all the heat which it contains, is sent through a feed-water heater, a certain saving may be effected of heat which would be otherwise lost. It is not, however, with heaters of these two general types that we are here concerned, but rather with those commonly called live-steam heaters, or, more properly, heaters employing steam drawn from the engine before it has done its full share of work, or before it has reached the full degree of expansion for which the engine provides. In order to consider the relation of such form of heater to the question of economy, brief reference must be made to the fundamental basis of steam-engine efficiency.

It will probably be remembered that the Carnot cycle stands as the highest ideal of engine efficiency. This cycle is simply the particular series of operations on the steam or other working substance which will give the highest economy to be attained between the given limits of temperature employed. Or, as we should say more exactly, an economy than which none can be higher between the same limits of temperature; since, as a matter of fact, there is a series of cycles, or ideal modes of operation, differing from the Carnot, and yet all having the same economy. The operations constituting the Carnot cycle are four in number and are as follows:

(1) The substance is allowed to expand at a constant temperature, and heat is supplied as may be required to fulfil this condition (iso-thermal expansion).

(2) The substance is allowed to further expand, but without allowing it to receive or part with any heat as such (adiabatic expansion). During this operation the temperature falls.

(3) The substance is compressed at the constant lower temperature reached in (2), heat being withdrawn as may be necessary to fulfill this condition (isothermal compression).

(4) The preceding operation is arrested at the proper point and the body is then further compressed without allowing it to receive or part with any heat as such (adiabatic compression).

During (4) the temperature rises and the operation is carried on until the substance is brought back to the same conditions as at the beginning of (1).

Now the actual engine is very far from working on such a cycle. Not a single one of the requirements is fulfilled, and in consequence a series of losses occurs. It follows that if the routine or cycle actually followed by the steam can be in any way so varied as to bring it a few steps nearer the Carnot cycle, or nearer any of the other derivative cycles which are of equal efficiency, then such a variation will result in a gain in economy; in transforming into work a certain amount of heat which would otherwise be rejected as heat and therefore wasted. Such variations, therefore, if possible, open a road for the saving of heat and the improvement of economy.

Into the further details of the theoretical side of the matter we cannot here go, and it must be accepted simply as a matter which may be proven by the proper use of the principles of thermodynamics, that if heat be taken from the steam during its expansion period and transferred over to the feed water during the period of its elevation in temperature, an improvement of the cycle may be thus effected. In order that the full ideal benefit of this transfer may be derived, the heat should be transferred at as nearly the same temperature as possible from the one part of the cycle to the other, and in such amounts as the particular circumstances may require. To do this in an ideal manner would require the use of an indefinitely large number of heaters so arranged that just near the end of expansion, say, a little steam could be withdrawn and its heat given to the feed water as a starter, thus raising its temperature slightly, or as nearly as possible up to that of the steam from which the heat was taken. Then following this, the feed water would receive a further accession of heat from steam previously drawn at a slightly higher point in the expansion, and so on, the feed water continually receiving heat from steam previously removed at higher and higher temperatures, and finally receiving its last addition from steam which had been removed just at the beginning of the expansion period.

Actually the operation is necessarily quite different from this ideal. Even in a multiple-expansion engine the number of points from which steam may be drawn is usually not greater than the number of stages in the expansion. Thus, in a modern step-by-step heater, fitted with a quadruple-expansion engine, steam may be drawn first from the low-pressure exhaust, a source having a somewhat higher temperature than the feed water as it comes from the condenser. Then, beyond this, steam may be drawn from the three receivers in reverse order, the last accession being drawn from the first receiver, and raising the water nearly to the temperature at this point in the expansion.

This operation, then, which seems like taking pennies from one pocket and putting them into another, is able to produce an economy simply because it does in fact bring about a change in the cycle which carries it a few steps nearer to one of the ideal cycles of maximum attainable efficiency. The details of just how this is effected would take us farther into the subject of thermodynamics than we can go in the present article.

One point must not be forgotten, that in a given engine the use of such a heater will mean the development of a smaller actual amount of power than if all of the steam were allowed to pass through the entire engine. While, therefore, the resultant power will be somewhat reduced, we may expect that what is developed will be at a somewhat decreased expense.

The amount of saving effected in any given case will depend on special circumstances, and, in general, we may remember that the more wasteful the engine is the greater the chance of saving, while as the engine becomes more perfect the narrower the margin left for possible gains. Under good conditions an actual engine may realize 75 per cent. of the ideal. That is, the heat wasted will be 25 per cent. of that theoretically utilized by the ideal engine, or 33 1/3 per cent. of that utilized by itself. Now if all losses and wastes separating the actual case from the ideal could be prevented, this entire 33 1/3 per cent. could be saved.

What part of the loss may be saved by means of such a feed-water heater cannot be determined by abstract computation, as it would depend on a balance of effects, about the details of which we have but little definite information. It is certain, however, that not all of the losses of the steam engine are of a kind which could be avoided, even by an ideally perfect feed-water heater, and furthermore, that the operation of the actual heater must fall far below that of the ideal, and hence that only a small part of the total loss can presumably be saved in any given case. There is, however, a definite and good expectation, based on thermodynamic principles, for at least a small percentage gain to be derived from the use of a heater working on these principles. Or, to express the thought in the reverse order, general experience seems to indicate the existence of such a gain under these circumstances, and in explanation of such a gain the principles of thermodynamics, as referred to above, may be properly invoked.

It is not alone, however, with reference to the operation of the engine itself that feed-water heaters are believed to produce beneficial results. There seems to be an opinion, wide-spread and somewhat definite, that the boiler itself is able to operate more efficiently with hot than with cold feed-water. In the present state of our knowledge, however, this is a point which must presumably rest upon general opinion rather than definite measurement.

The loss of heat at the boiler is, of course, the heat which escapes by way of the stack; the heat which is not transmitted to the water by the heating surface. Now, if by the use of hot feed-water, with the resulting greater uniformity of operation, the heating surface is able to act more efficiently, and to transmit more heat than if the feed-water is cold, with the consequent decrease in the uniformity of operation, then a source of gain will be found in the feed-water heater quite independent of its relation to the thermodynamics of the question. Beyond this there is undoubtedly a good claim for advantage in the use of the feed-water heater as far as reduction of the temperature range in the boiler is concerned. This reduction of range means a decrease in the internal stress due to temperature difference, and may be expected to be favorable to a generally longer life and more efficient condition as a mechanical structure than when the feed is introduced cold.

We may now consider the question of the use of a feed-heater using prime steam, or steam from the steam pipe or boiler, pure and simple. In such case the steam is used before it has done any work whatever in the piston, and it will not be difficult to see that there will be no thermodynamic gain, since the operation is the same as though the heater were made a distinct adjunct or part of the boiler itself. In other words, so long as the steam is of the same temperature and pressure in the two cases, it will make no difference whether the operation takes place in the feed-heater or in the boiler; and hence the use of such a heater will bring about the same result and will require the same heat exchanges as when no heater is used and the feed is put into the boiler direct and there raised to the temperature of the boiling point. While, therefore, in such case, we cannot expect a gain based on thermodynamic principles, the matter of gain based on the possible improvement in the operation of the boiler still remains, and may be a good and sufficient reason for the use of such heaters. In the operation of steam power plants the question may arise as to whether it is better to use the exhaust from all or part of the auxiliaries for feed-water heating, or to operate all of the auxiliaries condensing, and to look elsewhere for the steam for feed heating. If the latter mode is adopted, then, with the compound or multiple-expansion engine, the steam will naturally be drawn from the various receivers in accordance with the principles referred to above, while if the main engines are simple, the steam must be drawn from the steam pipe, and the operation becomes that of a live-steam feed-water heater using boiler steam, with only such gain as may be derived from the improvement in the operation of the boilers, as referred to in a preceding paragraph.

In regard to the question of which mode of operation will give the better economy, we may remember that in general it is better to operate a steam engine condensing, whether main or auxiliary. Therefore, the making of all engines condensing, both main and auxiliary, will give all the economy which is to be derived from this feature. We may also remember that an exhaust-steam feed-water heater is simply a more or less incomplete or imperfect condenser, and furthermore, that the more effective it is in raising the temperature of the feed-water, the less effective it is as a condenser; while the more effective it is as a condenser, the less effective it is as a feed-water heater. Both condensation and feed-water heaters are good things, but it is not desirable to combine both operations in one apparatus. Let all the steam possible be sent to the condenser and let its operation be as perfect and its temperature as low as can be maintained, for thus will the fundamental conditions for economy be fulfilled. Then let the operation of feed-water heating be carried on as a separate and independent part of the cycle.

The step-by-step heater used with the multiple-expansion engine has undoubtedly the first claim for consideration, and such an arrangement, properly installed, may be expected to give all the advantage to be derived from the matter of feed-water heating. If the engines are simple, and therefore without receivers from which to draw steam for the heater, then the supply may be taken from the steam pipe or boiler with the assurance that there will be no thermodynamic loss, and such gain as may be obtained from the possible better operation of the boilers, as already noted.

We may, therefore, conclude that the combination of features most favorable to all around economy in the general case of the development of power by the use of steam engines and boilers will include the operation of main and auxiliary engines condensing, and the use of feed-water heaters drawing steam from the receivers of compound engines, or from the live-steam supply of simple engines.

THE WEAK SPOT IN INCANDESCENT ELECTRIC LIGHTING FROM CENTRAL STATIONS.

BY FRANCIS W. WILLCOX.

What is responsible for the generally poor quality of incandescent lighting? No one having an extended acquaintance with the central stations of the country can fail to acknowledge that the service of incandescent lighting in the majority of central stations is miserably poor. In some of the larger cities, there is a high-class lighting service, as well as in exceptional stations here and there. Such cities and towns, however, form but a small number in the large aggregate of those inflicted with a most inferior quality of lighting service.

What is meant by a poor service is a dim, dull inferior lighting effect, the lamps giving from one-fourth to one-half of their rated light. Such is the general condition. Some scattered lamps may be found burning brightly, but they serve only to accentuate the dullness of the general effect.

What is the cause of such a condition? How do companies whose business it is to make and supply the commodity known as light, so mismanage as to deliver to customers not over one-half what is due them? A visit to these central stations will generally reveal good machinery, well and economically operated. There is nothing wrong here; good engineering has not spared expense in providing and maintaining the necessary steam and electric apparatus for a good lighting service.

An examination of the feeding and distributing system, the transformers and all connections will generally show a serviceable system, which, while not perfect, can nevertheless be made to give fair results. A test of the voltage at the sockets shows an average of nearly correct pressure maintained at the lamps, and that the energy necessary to give full lighting effect is there supplied. There is no serious lack here. Where, then, is the loss?

Surely with good and well-operated station apparatus, with distribution system giving a fairly uniform pressure at the lamp-sockets, we should expect a clear, bright lighting service. But the lighting service is not bright; on the contrary it is dim and very inferior. It is obvious that something essential has been forgotten or neglected. There remains one detail to be considered, namely, the condition of the lamps themselves. It is evident that if they are not all right, all previous efforts are brought to naught.

On looking into the matter of lamps we find in the first place that most of the lighting companies do not own this necessary piece of apparatus. The lamp is sold to the customer and he owns and controls it; the company thus places results entirely in the hands of the customer, and all efforts to maintain a good lighting effect are thereby nullified. After all the care taken to economically generate current and properly distribute it at the correct pressure, the results are deliberately left for the customer to determine. This is like providing locks and bars to a house and then handing the keys to strangers. The customer may and generally does buy an inferior type of lamp, because he can get it cheap. Here is an immediate cause of poor results.

The customer will seldom, if ever, renew a lamp until it burns out and he has to buy another. Here is a fruitful and continuing cause of poor results. Old dim lamps are retained in service and burned until they are black in the face, and like Humpty-Dumpty, all the central station's horse-power and men can never make them bright again. So long as the customer has to buy the lamps these conditions will prevail to the deterioration of good lighting. The only thing that can correct them is to remove the cause; that is take the lamps out of the control of the customer. This is best done by the lighting company supplying all lamps free of cost to the customer.

The lighting manager is the one to select the proper type and make of lamp for service on his circuits; this important question cannot be intelligently decided by the general customer. If left to the customer he will almost invariably select the lamp that is the cheapest and that will last the longest; in other words, the poorest grade of lamps. This results in loading the circuits with lamps giving varying candle-power, involving uncertain (generally very high) watt consumption and suffering a rapid loss in candle-power. The lighting service will be bad as the lamps, and the customer and the public will condemn the service, and rightly blame the lighting company therefor. It is just as much a part of a lighting company's business to supply a good lamp as it is to supply the current to light it.

There is a large number of stations that control the kind of lamp used, by selling it at a nominal figure. This is unquestionably a better practice than attempting a profit by the sale of lamps at high prices, and forcing customers to buy cheap makes. The first essential in good lamp service should be to have no lamps used but the one type selected as best. This is secured by the system of charging the consumer cost, or less than the cost price of the lamps. The real essential, however, of good lamp service is the full control of lamps, to provide for renewal of dim lamps. This is not, and never can be, secured as long as lamps are charged to the customer. Experience has shown that even with lamps sold for five cents, the average customer never renews them except when his lamps burn out.

Here is "a condition and not a theory," confronting electric lighting companies.

Lighting results are directly dependent upon the lamps; lamps are all subject to deterioration, some in greater degree than others. Lighting results are, therefore, bound to deteriorate in the same degree as the lamp. To maintain lighting results, the lamps must be maintained; lamps cannot be maintained when the customer has to buy them. Therefore the central station desirous of maintaining a high character of lighting service, must supply free lamp renewals.

The remedy is a simple and plain one. The question that lies at the root of the matter is that of expense. Can central stations afford to take over the supply of lamps on a free renewal basis? This question can be answered most positively in the affirmative for all meter systems. The question really is not whether stations can afford to supply free lamp renewals, but, whether they can afford not to. When one considers what a small part of the cost of light the cost of the lamp represents, it seems strange that any manager should ever hesitate over the question.

Take the case of a 16-c. p. 55-watt lamp burning the useful life of 600 hours. In this time it has consumed 33 kw.-hours. If the station rate is 15 cents per kw.-hour (¾ cent a lamp-hour) it represents an income of $5, which is 25 times the cost of a lamp. Can any station man seriously doubt that it pays to spend 20 cents to insure and hold $5 worth of business? If the station produces current at as low a rate as ⅜ or ¼ cent per lamp hour, the cost to the station of this 600 hours' supply is about ten times the cost of the lamp. Can anyone doubt that it pays to expend the one-tenth (in free renewals) and get the full value of the remaining nine-tenths, as against attempting to save the one-tenth, and thereby depreciating the value of the other nine-tenths?

With lamps costing 20 cents (which is above the average price that central stations pay) the cost per hour for 600 hours of service is 1/30 of a cent, or about 2/3 of a cent per kw.-hour. If, therefore, a station should adopt free renewals, it could cover the cost by the slight increase of 2/3 cent per kw.-hour in its meter rate. The improved results from free renewals would render it generally an easy matter to charge this increase. Or free renewals could be adopted, when reduction of rates becomes advisable, in place of a reduction in the meter rate. In point of fact, the beneficial results of free lamp renewals secure income returns far in excess of their small cost, and there is hardly any central station that could not profitably adopt free renewals without the necessity of any increase in rates.

An improvement in lighting service of more than 50 per cent. becomes possible at once with free lamp renewals. Is not two-thirds of a cent per kw.-hour a small price to pay for such a result? Such an improvement means an increase of business, satisfied customers and absence of complaints. Aside from this great gain, free lamp renewals aid in swelling the meter income in several ways. First, by keeping all sockets replenished with good, new lamps. With lamps charged for, a large number of dead lamps are left in the sockets, yielding no return in service. Second, by cutting off all allowances and reductions on bills. Such reductions are the natural result of complaints due to an inferior lighting service. Customers will, it is found, cheerfully pay a bill for good lighting service against which they will protest most vigorously if the service is poor. Third, it assists in the maintenance of good and profitable rates by making the service superior.

It is time that central station men should take up this lamp question. Improvements in station apparatus and line and transformers have in recent years absorbed most of their time and attention. These improvements having been accomplished, there remains no longer any excuse for the neglect of the lamps. Besides, the improved results resulting from proper attention to the lamps are more immediately and directly evident to the patrons and public at large, upon whom the central station depends for business, than improvements in station apparatus, or in any other department. The proper supply and renewals of lamps will assist the poorest stations to maintain a good lighting service, while without attention to this detail the best equipped stations are unable to give such a service.

This difficulty cannot be evaded by an effort to lay the blame on the customer by claiming if he does receive poor light it is his own fault. The average customer does not and cannot understand lamps or correct lamp service. If he receives poor light, he naturally blames the lighting company, and very rightly, too, since the lighting company should never allow a condition that yields poor light. In the meantime the poor results rendered through this condition are condemning the service with the general public.

It is time that central stations learned that they waste more through inattention to their lamps than they save by many of the improvements in their stations. There is no department of central station service where a little care and attention yields such marked and immediate improvement as the incandescent lamp department.

The manager of one of the largest lighting companies in New England gives it as his experience that "no one detail of my service has ever yielded me such excellent returns as the free supply and regular renewal of my incandescent lamps."

While the expense side of electric lighting is very important and warrants care and attention to every detail, yet a majority of stations waste more money through mistaken and faulty methods of selling light and supplying lamps than they do in generating current. Time and money will be most generously expended to secure a saving of two or three-tenths of a cent per kw.-hour at the station, and then because it costs a few hundred dollars a year to supply free lamp renewals, a policy will be adopted which will effectually waste double this saving at the customer's end through depreciation of the lighting service. What is needed in all central stations is an incandescent lamp department, just as there is an arc light department, and a meter department. This incandescent lamp department should be responsible for the condition of the incandescent lighting and have charge of lamp renewals. In small stations this work might be included under the meter department.

With free lamp renewals the work of such a department would be as follows:

(1) The systematic taking out of all lamps at proper periods and replacement by good lamps. (2) The photometering (very easy and rapid work) of lamps pulled out and the sorting out of those lamps measuring above any agreed limit, say 13 c. p., for re-issue. After cleaning and buffing, such lamps can be installed again in the next exchange.

By some such system the lighting service can be maintained clear of dim lamps, and kept clean and bright—the only condition under which the best lighting is possible. Free renewals regularly and frequently made is the policy and practice of the leading central stations of the country, and this practice has built up a standard of lighting service superior to any in the world. The opposite policy, compelling customers to buy their own lamps, is responsible for the very poor electric lighting service to be found abroad and in those American stations that apply it. Free and liberal lamp renewals should be the invariable policy of each and every lighting company with meter customers.

MOTOR-CONTROLLED ENGINE GOVERNORS.

The Boston Electric Light Company is fitting the large engines in its central generating plant, in South Boston, with small motors for giving the switchboard attendant a means of controlling the governors. Readers of these columns may remember from the description given in the issue of June, 1899, that this station contains a number of vertical McIntosh & Seymour cross-compound engines, rated at 1350 h.p. each, and running at 120 r.p.m., direct coupled to 60-cycle alternators. In order to give a means of synchronizing with the shaft governors rather than with the throttles, as well as to adjust the division of the load between units, each engine shaft was originally fitted with a loose collar which, when retarded by a friction brake, would turn a screw varying the tension of one of the leaves of the governor spring, thus changing the speed at which the governor would tend to hold the engine. This device proved too quick in its operation, besides having the disadvantage that it was not controllable from the switchboard. Under the new arrangement there is securely strapped to the hub of the fly wheel of each unit a direct-current motor of the size commonly used on desk fans. Through a spur and worm-gear reduction this motor drives a screw which tightens or loosens the spring which counteracts the centrifugal force of the shaft governor weights. A friction clutch is provided in the gear train to prevent the motor from causing damage if its motion is continued beyond the limit of travel of the screw. The motor receives its current through four collector rings on the main shaft, immediately beside the collector rings of the revolving field, the four rings being used in order to make the machine reversible. The circuit is controlled by a small triple-pole double-throw switch on the generator panel of the main switchboard. By throwing this switch up, the motor is run in one direction, stiffening the governor spring, and thereby increasing the speed of the unit; throwing the switch down causes the reverse action. With the switch open the motor remains stationary, owing to the screw and worm gear. This gives a ready means of synchronizing with the governor, which is preferable to synchronizing with the throttle, and puts the control of the engine speed directly into the hands of the switchboard attendant. In starting up a fresh machine and synchronizing it with one or more already running under load, the governor of the new machine will, of course, tend to adjust its engine to the normal speed of 120 r.p.m.; those under load will, however, be running at about 118 r.p.m., owing to the 2 per cent. regulation drop. This gives the synchronizing lamps about one beat per second. To pull the fresh machine down to the speed of those on the bus bars, its governor spring is slacked off by means of the motor described above. If brought down to exactly the same speed, and thrown in, the new machine will take none of the load until its governor spring is again tightened up, tending to pull in the governor balls and admit more steam at the speed at which all the machines are running in synchronism with each other. The motors give a ready means of shifting the whole or any portion of the load from one machine to another at any time, and of gradually throwing the load entirely off from any machine before opening its switch to shut it down. In this way a generator can be cut off from the bus bars without affecting the load on the others in parallel with it at the instant when the switch is opened, and thereby without disturbing the voltage.

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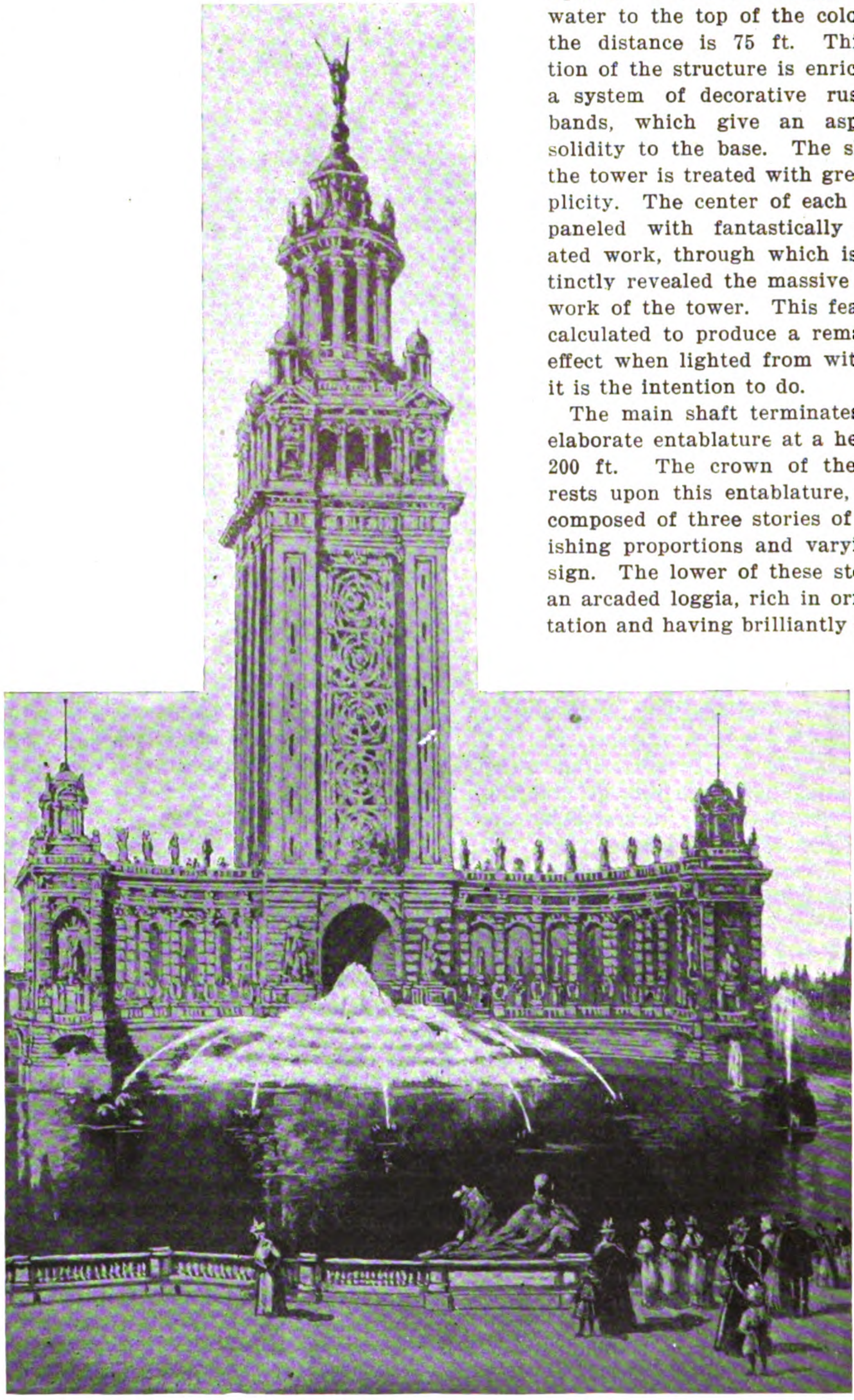
A New Long-Distance Transmission Plant in Canada. — It is reported that the Shawinigan Water & Power Company will, during the coming summer, complete the works which have been in process of construction for some time past for the transmission of power from Shawinigan Falls to Joilette and Montreal. The plant, it is said, will develop 30,000 h. p. The transmission line will be about 80 miles long and will parallel the Great Northern Railway as far as Joilette, whence the course will be an air line to the end of the island of Montreal.

THE ELECTRIC TOWER AT THE BUFFALO EXPOSITION.

The great Electric Tower, which will be the conspicuous center-piece of the Pan-American Exposition at Buffalo next year, will present an imposing and handsome appearance. The height of the tower is 348 ft. above the surface of the broad basin in which it stands. Its position is between the Court of the Fountains and the Plaza, on the north side of the Mall. It looks down upon the Agricultural Building at the east and the Electricity Building on the West. The tower proper is flanked on the east and west by long curved colonnades, which sweep southward and terminate in airy pavilions, embracing a semi-circular space 200 ft. across. Within this space, and in a high niche in the main body of the tower are cascades, while all about the basin are leaping jets and countless playful figures, each with its spurt of water, combining to make a brilliant water scene. At the center of the niche is a tall geyser fountain, the water from which passes from the high basin within the niche over successive ledges and among a multitude of vases to the level of the pool.



THE ELECTRIC TOWER AS IT WILL APPEAR AT THE BUFFALO EXPOSITION.

The main body of the tower is 80 ft. square. From the surface of the water to the top of the colonnades the distance is 75 ft. This portion of the structure is enriched by a system of decorative rusticated bands, which give an aspect of solidity to the base. The shaft of the tower is treated with great simplicity. The center of each side is paneled with fantastically perforated work, through which is indistinctly revealed the massive framework of the tower. This feature is calculated to produce a remarkable effect when lighted from within, as it is the intention to do.

The main shaft terminates in an elaborate entablature at a height of 200 ft. The crown of the tower rests upon this entablature, and is composed of three stories of diminishing proportions and varying design. The lower of these stories is an arcaded loggia, rich in ornamentation and having brilliantly colored wall surfaces. Pavilionettes at the corners terminate in light fantastic cupolas. The second stage, or lantern of the tower crown, is in the forom of a high, circular colonnade, entirely open, so as to allow the effect of the sky to be seen between the columns. A spiral staircase within the colonnade leads to the last stage of the tower, the cupola. Over the cupola dome is poised a colossal figure of Electricity dominating the entire exposition, which owes so much to her generously exerted power. From the water up to the feet of the figure is a distance of 331 ft. The figure is 17 ft. in height.

The entrance to the tower is across an ornamented bridge from the Plaza, on the north side. Elevators will carry passengers to the various floors, which will be used for different purposes, such as reception rooms, offices, restaurants, belvederes and amusement halls. A large restaurant 200 ft. above ground, will give the diner a fine view of the exposition grounds and the surrounding landscape. From the cupola the eye can sweep the whole Niagara frontier.

Sculpture plays an important part in the decoration of the tower. Two monumental groups of statuary flank each of the four sides of the base. Above the water niche in the southern face of the tower is a magnificent escutcheon, representing the arms and seal of the United States. In the spandrels of the arch above the niche are sculptures in high relief. The pavilions and wings are also richly decorated with sculptures and other architectural devices. The entire exterior of the tower will be studded with electric lights, so arranged that a great variety of effects can be secured.

Among Our Foreign Contemporaries

An Accumulator Charge Indicator.—It would often be very desirable to have a simple and exact device which shows at any moment the condition of charge or discharge of an accumulator. To a certain degree this condition is indicated by the color of the plates. A voltmeter is very servicable for indicating the end of a charge or discharge, but not the intermediate states. The only practical means for indicating the latter, seems to be to determine the specific gravity of the electrolyte. Hydrometers are used very much for that purpose, but the drawback is that when near the bottom of the battery, their sensitiveness is small, while when in the upper layers of the electrolyte their indications may give wrong results, as the density of the electrolyte in those layers varies greatly; moreover, it is not at all uniform at different depths of the electrolyte. In a recent issue of a new German contemporary, the "Centralblatt fuer Accumulatoren und Elementenkunde," Prof. Bellati of the Engineering School of the University of Padua, suggests the use of a simple apparatus, which is based upon the well-known principle that, when two vessels, filled with different liquids, are in communication with each other, the height of the liquid in each over the separating surface is in inverse proportion to their density. In Fig. 1, the horizontal line through D marks the surface of the electrolyte; A A A is a glass tube, which, through a hole, F, on its lower side, is in communication with the electroltye. On its upper side a capillary tube, A B C, is fixed, the part, A B, being vertical, and B C, nearly horizontal. This tube is filled with petroleum which is lighter than the electrolyte and does not mix with it. The horizontal line, A A A, represents the surface of separation between the electrolyte and the petroleum. Then a column of electrolyte of the height, D A, exerts as much pressure as a column of petroleum of the height, M A, so that with a change of the density of the electrolyte the height, M A, varies. The portion, B C, of the glass tube has a scale, on which the position of the end, M, of the petroleum is read. This scale may be so chosen that its two ends represent full charge and discharge, and the intermediate space may be graduated in ampere-hours.

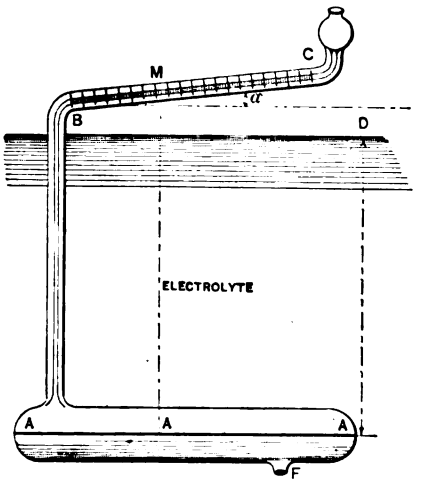


FIG. 1.

Measuring Instruments in High Tension Plants.—In a recent number of the "Elektrotechnische Zeitschrift" Mr. F. Widmann criticises Mr. Schueler's method of connecting the measuring instruments in a high tension plant, which was described and illustrated in these columns of the February issue. This method is said to have the disadvantage that the ratio between the e. m. f. of any part of the armature winding and the whole e. m. f. generated in the armature is not a strictly constant value; he agrees that Schueler's method is very simple and not dangerous, but says that the same results may be obtained with the aid of small auxiliary transformers with which the high e. m. f. of the machine and the current, are transformed. This method, which is used by several firms, is illustrated in Fig. 2. The primaries of the two voltage transformers are supplied with the whole voltage of the two machines M. I. and M. II., while the secondaries give 55 volts and supply the voltmeters, V, V. By the switch, S, the circuit of the 110-volt phasing lamp, PhL, is closed, and it glows brightly when the machine to be connected is in synchronism. The two current transformers, C T, transform the current of the machine to a few amperes; and A^1 and A^1 are ammeters, A, is the main ammeter and W, the wattmeter. The shunt of the wattmeter is fed from the secondaries of the voltage transformers and connected to them by the switches, s, s. These switches are linked together with the levers of the machine switches, so that when one machine is disconnected the connections with the secondaries of the voltage transformer are also interrupted, in order to prevent its excitation from these secondaries. All transformers may be so designed that neither the transformed e. m. f. nor the transformed current has a great difference of phase with the current of the machine; therefore the wattmeter may also be connected to the low tension circuit. Mr. Schueler replied that the inaccuracy of his method, as pointed out by Mr. Widmann, is without practical importance and that his method is more simple than that of Mr. Widmann, while neither one is dangerous; in Mr. Widmann's method the indications of the wattmeter are inaccurate on account of the phase differences produced by the transformers.

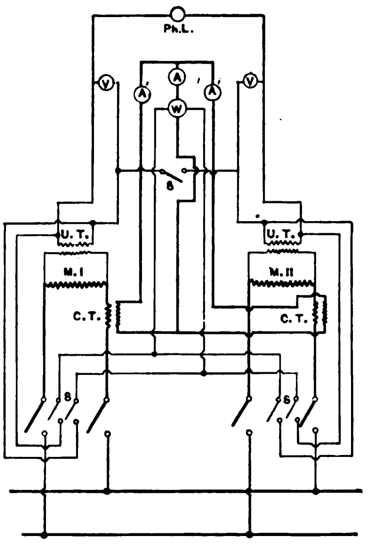


FIG. 2.

A Fault Test for Insulated Wires and Cables.—Recent issues of English contemporaries notice a British Physical Society paper of Mr. Appleyard, describing a method which enables a fault in the insulation of a cable to be found without the removal of the braiding or tape. The cable is wound on two insulated drums or tanks, the intermediate stretch of cable being about 10 ft. long. One end of the core is left unconnected while the other is grounded through a galvanometer and a battery. A tap wire is connected from a point between the galvanometer and the battery to a point on the insulation of the stretch of wire between the drums. A wet cloth, connected to an earth wire, is laid on the coil wire on one of the drums and the galvanometer deflection is observed. The grounded cloth is then applied to the coil on the other drum, and the corresponding deflection is noted. A comparison of these deflections indicates the drum upon which the fault lies. With the galvanometer still deflected, the wire may be run through a suitable contact brush or sponge attached to the tap wire. The instant the fault passes under the tap wire contact, the deflection falls and the fault is located. One advantage of the method is that at the critical moment when the fault passes under the tap wire contact sponge, the galvanometer is short-circuited through the fault and is thereby completely protected.

An Electrolytic Centrifugal Process for the Production of Copper Tubes.—One of the most efficient workers in practical electrochemistry in England is Mr. Sherard Cowper-Coles. In both the January and March numbers we referred to his recent work in connection with the electrolytic deposition of zinc. Recent issues of English journals reproduce a paper read by him before the British Institution of Electrical Engineers and describing his new and very interesting electrolytic process which is now being worked on a practical scale for copper refining and the manufacture of copper tubes, sheets and wire. It has been the object of those engaged in the electrolytic refining of copper to increase the current density as much as possible, so as to get a larger output per vat; the accomplishment of this is one of the features of the present process, which produces smooth tubes 12 in. in diameter at the remarkably high current density of 190 amperes per sq. ft., the voltage being from 1 to 1.2. No burnishing tools are used, but the cathode on which the copper is deposited is revolved at a high rate of speed, the result being that the skin friction between the deposited metal and the electrolyte keeps the copper beautifully smooth. Any gas bubbles evolved at the cathode or impurities in mechanical suspension in the electrolyte which would have a tendency to settle on the cathode, are thrown off by centrifugal force. The process allows a hot and more acid solution to be used than is generally employed. The amount of free acid has a very marked effect upon the voltage required, but a very small effect upon the actual weight of copper obtained, compared with theory. A hot solution allows a larger current to pass at a much lower voltage, 150 deg. F. being probably the most economical temperature. The possibility of using high current densities has the incidental advantage of enabling the anode sludge to be worked almost immediately, thus making the working up of the silver or gold easier, quicker and more economical. The apparatus used in this process is shown by Figs. 3 and 4. There is a wooden vat, A, in which are placed anodes of crude copper. The cathode is a hollow mandrel, B, made of brass, which is supported on a revolving shaft, C. The shaft is brought through the bottom of the vat to the top of the cell and is protected from the copper sulphate solution by a lead-casted wrought-iron column. The shaft is caused to revolve by gearing placed beneath the depositing cell, the speed varying with the size of the mandrel. The mandrel at the end is fitted with an eye-bolt, D, for lifting purposes, and a circular brass casting, E, against which the contact brushes, F, press for collecting the negative current. The brushes are fitted to the arm, G, which are made to turn back in order to permit the easy withdrawal and insertion of the mandrel. A baffle plate, H, made of an insulating material, is placed at the bottom of the mandrel to prevent the formation of copper "trees" or nodules. The electrolyte is briskly circulated through the cells by means of an acid-proof pump or air-pump, the solution being pumped to a reservoir, where it passes through a filter to rid it of all impurities in suspension. When it is desired to obtain a sheet of copper, the tube removed from the mandrel is cut, flattened out, and annealed. For producing a wire, a piece of insulating material is wound round the mandrel in the form of a spiral, and the copper is deposited between the threads until the thickness of copper is equal to the distance between the threads; the spiral is then removed, and after annealing is drawn out in the usual manner. The mandrel is given a small taper and is slightly greased to facilitate the removal of the tube.

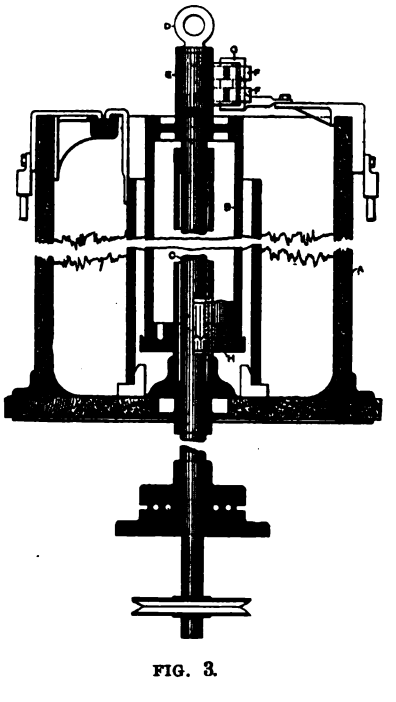


FIG. 3.

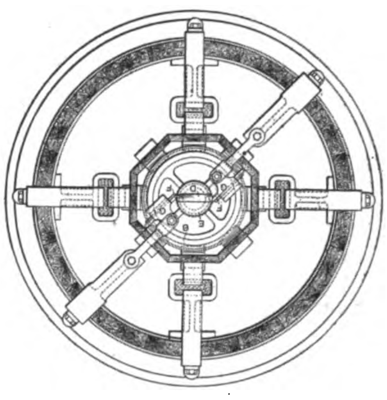


FIG. 4.

Accumulator Traction.—Several foreign contemporaries deal again with the question of accumulator traction. In "L'Industrie Electrique" Mr. Buse gives a long description of the accumulator system in the city of Ghent. He reaches the general conclusion that accumulator traction is practical in the country and in towns in which the interval between cars is relatively great; on important city streets its use is prohibitive on account of the waste of time in bringing the cars back to the station for recharging the batteries. Charging stations in the center of a city are thought to be impracticable on account of the cost. He remarks that another great disadvantage of accumulator traction is the fact that the acid ruins the cars. In Ghent he noticed that new cars were badly damaged after a service of only three months, in spite of all efforts to protect them.

In an article in "Cosmos" Mr. Battandier deals with the situation in Rome, where the tramway company is about to replace accummulator traction by the trolley system. The company has been using the Pescetto accumulators. The objections made to the accumulator system are the well-known ones: the loss of time by charging, the great frailty of accumulators which makes it necessary to take the greatest care with them, their weight, the odor which appears to have annoyed passengers very much, and the high cost. A remark is made that the high cost may have been the principal cause for the present change; the accumulator system was not a success in Rome because the company did not wish it to be a success. The situation appears to be similar to that in Berlin, where, during the last winter's storms, the combined trolley and accumulator system broke down, not on account of any fault of the accumulators, but because there was an insufficient supply of current from the power house; the companies tried to extend the trolley system into the accumulator districts, by arousing popular feeling against the accumulators in the newspapers. In both of these cases the municipal authorities had forbidden the trolley system in certain streets.

In an article of the "Elektrotechnischer Anzeiger" Mr. Elsner describes the behavior of the accumulator system of Bremerhaven in Germany in a blizzard in February, which proved very satisfactory in spite of topographical difficulties. During a day on which there was a heavy snowstorm, the service could be maintained although the snow was not removed from the rails. The rails were fully covered with snow, pressed down by the weight of the car, so that the wheels did not touch the rails themselves. It is apparent that a trolley system with rail returns, or a combined trolley and accumulator system would have failed in this case.

Automatic Pressure Regulator.—In a recent issue of the "Elektrotechnische Zeitschrift" Mr. E. Dick describes a new automatic pressure regulator devised by himself. The action is based on the rising and falling of a solid iron plunger, the lower part of which is enclosed in an insulating cover and dips into mercury contained in a contact case, while the upper part is in the inside of a solenoid. Movement on the part of the plunger may be caused by one of three forces: The magnetic attraction of the solenoid upon the iron core, the mechanical force tending to make the iron core float upon the mercury, and the total weight of the core. The weight of the core mechanism can be adjusted by a special mechanical device, shown in the adjoining figure at the upper end of the iron core. The contact case, which is filled with mercury, contains a number of contact plates separted by insulating micanite plates, the former being connected to the different points of a resistance in the field circuit of the dynamo. The movements of the iron cylinder cause a falling or rising of the mercury, and therefore cut these resistances in and out of the circuit, thereby regulating the field current of the dynamo.

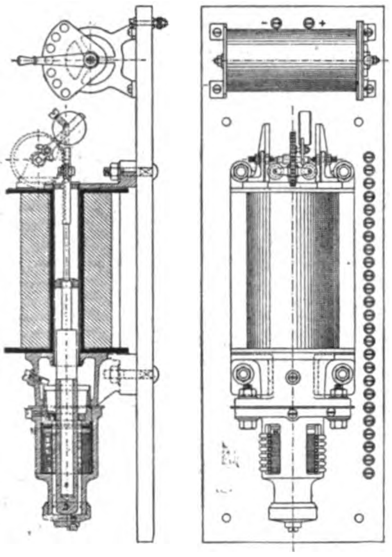


FIG. 5.

Three Phase Trunk Railway.—In a recent issue of the "Zeitschrift fuer Elektrotechnik" of Vienna, there is a description, by Mr. Neudeck, of the line now under construction between Lecco, Colico, Sondrio and Chiavenna in Italy. This line is of special interest, as it is to be operated by three-phase currents. It is being built by Ganz & Co., Budapest. The total length of the line is 70 miles. The energy is generated in a water power plant on the river Adda, the output of which varies between 3000 and 6000 h. p., according to the season. Three-phase currents at 15,000 volts are transmitted by overhead wires to 10 substations along the line, where the voltage is transformed down to 3000 for use on the trolley wire and cars. The distance between two substations is about 6.3 miles. The current is supplied to the motorcars by two overhead wires three feet apart; the rails form the third conductor. This is said to be the first case in which such high voltages are used on the trolley wire. The whole line is divided into single parts, each of which is supplied with current from the substation next beyond it; this is done to insure safety. When one block signal indicates "stop," the next part of the line is not supplied with current, and in the case of interruption of current the Westinghouse brake begins to act automatically, which is an important feature on parts of the line with steep grades. Each motorcar has four motors, but in general the car is driven by two motors. On serious grades the other two motors also drive, being supplied with current, not from the trolley, but with that generated in the armatures of the first two motors; by this method the speed is reduced to one-half without loss of energy. The normal speed is 36 miles an hour for passenger trains and 18 miles for freight trains; by the method described this is reduced on grades over 1 per cent. to 18 and 9 respectively. The passenger trains consist of one motor car and one trailer, the maximum load being 65 tons. The freight cars, having a maximum capacity of 200 tons, are driven by a locomotive car.

Calcium Carbide.—As was noticed in the March number, the developments of the calcium carbide industry has been very rapid in the last few years, so that it may be of interest to examine the commercial outlook for a more extended practical use of acetylene. In a recent number of the "Elektrotechnische Zeitschrift" Mr. E. Neuberg gives a comparison of the cost of lighting, cooking, heating and motor driving with electricity and with acetylene. The cost of electricity is based upon the charge of the Berlin Electric Works, which are 13¾ cents per kw.-hour for lighting and 4 cents for cooking, heating and motor driving. The cost of acetyelene is based upon a price of 4 cents per pound of calcium carbide. He finds that 1000 kg.-calories are supplied by the Berlin Electric Works for 15.9 cents for lighting and for 4.6 cents for cooking, etc., while if generated by the combustion of acetylene, they cost 4.2 cents. In this respect acetylene appears to be superior to electricity, but to make the comparison complete, it is necessary to properly consider the efficiency of the apparatus and machines, such as lamps, cooking apparatus and motors.

By doing so, he finds that one Hefner candle-power from an incandescent lamp costs 0.038 cent, and from an acetylene lamp 0.030 cent, the life and the price of both lamps being equal, so that acetylene lighting is somewhat cheaper than electric lighting. The introduction of a more efficient electric incandescent lamp, however, such as the Nernst lamp, would reverse the situation in favor of electricity. The cost of heating 3 lbs. of water from 30 degs. to 92 degs. C. by electricity is 0.47 cent by actylene 0.69 cent; moreover, electric heating and cooking is not only cheaper, it is also cleaner and much more convenient. For an electric motor one h. p.-hour costs 3.64 cents; for an acetylene motor, 8.78 cents; if besides this, amortization, the consumption of oil and cooling water, the attendance, and the efficiency, as a function of the load, are properly taken into account, the price of the h.p.-hour is increased far more for the acetylene motor than for the electric motor. It appears, therefore, that acetylene cannot compete with electricity for heating and power purposes.

Electric Tramway Rail Testers.—In a recent issue of the London "Electrician" a rail tester, invented by Lord Kelvin, is described, for making conductivity tests of tram rails, detecting faulty bonds, etc., on electric tramways, where the rails are used for the return currents. As shown in Fig. 6, herewith, contact is made on the rails by a graduated bar which has attached to it two steel contacts. These contacts are provided with terminals, and are connected by means of a flexible wire to the terminals of a low-range voltmeter, which is contained in a light case with carrying straps. The lid of this, when opened, forms a desk, and on it are provided two paper clips to hold the test sheet. A convenient handle is also provided on the contact bar. The indications of the instrument show directly the resistance of the rail bond or section of rail. Various degrees of sensibility can be obtained by altering the position of the contacts on the contact bar. Further than this, no description is given; presumably the current in the rail is assumed to be constant while one measurement is made of the joint and another of an equal length of rail.

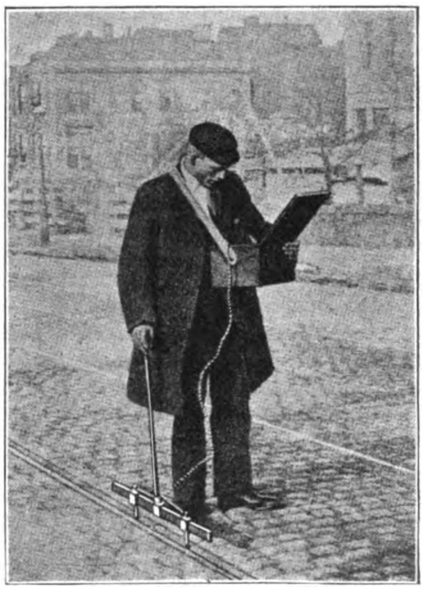


FIG. 6

Variable Resistance and Charging Board for Accumulators.—In an article in the London "Electrical Engineer" on portable accumulators of English make, for medical and surgical work, there is a description of a handy form of variable resistance which is illustrated in Fig. —. The resistance is made up of a series of carbon discs interleaved with discs of metal, which are slightly bent so as to maintain a spring pressure on the carbons. The screw seen at the left hand of the illustration is made with a very fine thread so as to secure fine adjustment. The metal and carbon discs are enclosed in a vulcanized fibre envelope pierced with holes so as to let the heat escape. The addition of the metal discs allows a wide range of resistance to be obtained, which is very desirable in connection with surgical work, where electric cautery, etc., require heating to an exact temperature.

In order to facilitate the charging of the accumulators, the same makers have introduced and standardized a charging board, also shown in Fig. 7. Two of the four terminals of this board are connected to the charging mains, and two go to the battery. The incandescent lamp in the middle of the board is connected in series with the accumulators. When the charging mains have been connected up, the terminals to the battery are short-circuited, and then the small needle between these terminals indicates which of them should be connected to the positive terminal of the battery. This combination of a pole indicator with the lamp resistance makes it an easy matter to connect up the accumulators in the right way for charging and prevents reversing them.

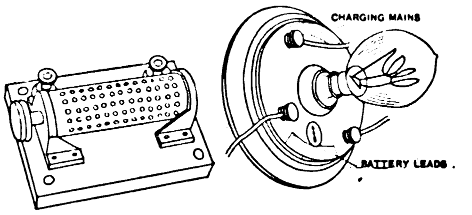


FIG. 7.

The General Electric Company's Annual Report

The General Electric Company issued its eighth annual report on April 21st. The president's report pointed out that during the past year there has been a rapid growth of profits in electric railway and lighting company's securities. The result of this condition has been to stimulate the production of electrical apparatus such as the General Electric Company builds. The president's summary of profits and additions to the surplus account is as follows:

Profits for the year (including $838,857.73 profit derived from the sale of securities) after deducting all general, patent and miscellaneous expenses, expenditures on patents, allowances for depreciation losses	$5,479,130.20
Dividends on preferred and common stock and interest on debentures	1,282,670.67
Difference	$4,196,459.53
Reduction in patent account	2,000,000.00
Net addition to surplus account	$2,196,459.53

The report of Mr. Eugene Griffin, first vice-president, covering the operations of the sales department, shows total sales of $22,379,463.75, on which there was a manufacturing profit of $3,805,860.18, independent of items on the profit and loss statement. The increase over the previous year's orders was 51 per cent., as compared with 21 per cent. increase last year over the preceding year. The year's orders included upwards of 10,000,000 incandescent lamps, and at the close of the year the books showed the aggregate of 11,807 customers. Approximately 87 per cent. of the year's orders were taken at the standard terms of payment, namely, cash in 60 days.

The report of the second vice-president, Mr. J. P. Ord, relating to the finances of the company, shows an expenditure for new patents and patent litigation of $353,333.87. In the previous annual report, patents, franchises and good-will were carried at $4,000,000, and at the expiration of the fiscal year covered by the present report half of this sum and all of the year's expenditures were charged off to profit and loss, leaving standing on the company's books $2,000,000 against patents, franchises and good-will. The book value of the factory plants, deducting depreciation, is given as follows: Schenectady, $2,300,000.90; Lynn, $900,000.80; Harrison, $200,000.30; making a total of $3,400,002. The cost of plant additions during the year was $1,330,428.40. The sales of securities amounted to $2,678,409.03; these had been carried on the books at $1,839,551.30, so that the sales show a profit of $838,857.73, as indicated in the president's report. The money realized from the above sale of assets was expended upon extensions to the factory plants; in purchasing $400,000 of the company's debenture five per cent. bonds at an average cost of $117.68, and in protecting and improving existing investments by acquiring miscellaneous stocks and bonds of the aggregate value of $1,693,400, the cost of these stocks and bonds to the company being $1,274,428. The company has no outstanding notes payable; its accounts payable, including all unpaid audited indebtedness, aggregate $1,003,364.05.

Mr. Ord's report also shows total accounts and notes receivable aggregating $7,315,122.12, from which was deducted an allowance of $337,119.82 for possible losses, leaving the estimated notes and accounts receivable valued at $6,978,002.30, net. The work in progress is valued at $1,024,552.60,

Consolidated Balance Sheet of January 31, 1900.

ASSETS.			
Patents, Franchises and Good-will			$2,000,000.00
Factory Plants			3,400,002.00
Real Estate (other than factory plants)		$ 563,643.44	
Stocks and Bonds		6,132,268.04	6,695,911.48
Cash			1,537,071.86
Notes and Accounts Receivable		6,978,002.30	
Work in Progress		874,128.36	
Inventories:		7,852,130.66	
Factories	$7,264,666.01		
General and Local Offices	737,580.23		
Consignments	45,334.85	8,047,581.09	15,899,711.75
			$29,532,697.09
LIABILITIES.			
Capital Stock:			
Seven per cent. Cumulative Preferred		$ 2,551,200.00	
Common		18,276,000.00	$20,827,200.00
5% Gold Coupon Debentures			5,300,000.00
Accounts Payable		1,003,364.05	
Accrued Interest on Debentures		44,166.67	
Unclaimed Dividends		4,935.85	1,052,466.57
Profit and Loss			2,353,030.52
			$29,532,697.09

Consolidated Profit and Loss Account January 31, 1900.

EXPENSES.		
Cost of Goods sold	$16,439,935.19	
General Expenses, Taxes, Depreciations, Losses and Allowances for Losses	2,136,668.38	
Patents and Patent Expenses	353,333.87	$18,926,937.44
Interest on Debentures*		281,666.67
Dividends Paid:		
On Preferred Stock—7% for the year	178,584.00	
On Common Stock—three dividends of 1½% each: paid July 15, '99, Oct. 14, '99, and Jan. 15, 1900	822,420.00	1,001,004.00
Patents and Good Will written off		2,000,000.00
Balance January 31, 1900 (Surplus)		2,353,030.52
		$24,562,638.63
EARNINGS.		
Balance January 31, 1899 (Surplus)		$ 156,570.99
Sales	$22,379,463.75	
Royalties and Sundry Profits	868,706.70	23,248,170.45
Dividends and Interest received on Stocks and Bonds owned	309,428.23	
Interest and Discount	80,322.06	389,750.29
Profit on sales of Stocks and Bonds	838,857.73	
Less Premiums paid for Debentures purchased and canceled	70,710.83	768,146.90
		$24,562 638.63

*On $5,700,000 for ten months and on $5,300,000 for two months.

upon which partial payments have been made aggregating $150,424.24, leaving a net worth of $874,128.36.

In the inventories of raw materials, goods manufactured and in process of manufacture, shipments in transit to store rooms of local offices and manufactured goods in such storerooms, the raw materials have been valued at the lowest price paid by the company during the last three months of the fiscal year ending January 31st, 1900; in cases where the market price prevailing on January 31st was lower than the lowest price paid during the three months referred to, the former valuation was used; active-selling, finished and partly finished apparatus and supplies were valued at estimated factory cost, and inactive or slow-selling apparatus and supplies were valued at about 50 per cent. of factory cost.

The report of Mr. E. W. Rice, Jr., third vice-president, covering the engineering and manufacturing departments, states that the great increase in orders received has taxed the factory facilities to the utmost, notwithstanding the liberal additions made to machinery and buildings; the large shops completed and equipped at the Schenectady works during the previous year, as well as the additions made during the fiscal year under consideration, are crowded with work. There were erected at Schenectady during the fiscal year a forge shop of 16,000 sq. ft. floor area, a storage building of 12,000 sq. ft., and additions aggregating 55,000 sq. ft. to the drafting room, patent shop, punching-press shop and brass foundry. An extension of about 40,000 sq. ft. to the large iron foundry (which was completed about a year ago) is now under way, and an extension of about 40,000 sq. ft. to building No. 23 has been begun; this extension is needed to take care of the increased demand for switchboards, controllers and similar apparatus.

At the Lynn works a further extension of 18,000 sq. ft. was made to the steel factory, and an increase of 7000 sq. ft. to the building devoted to meters and instruments is under way. The company had purchased 14 acres of land at the river works, Lynn, in order to provide for future extensions. At the Harrison works the large fireproof building mentioned in last year's report has been completed and is in full operation; the increase in the output of this building has been so great as to demand further extensions, which are now under consideration. Mr. Rice's report gives the total floor area of factory buildings at 2,000,000 sq. ft.

The report further points out that there has been a marked increase in the size of direct-current electric generators for lighting and power service over moderate distances, and that the revolving-field type of alternator with stationary armature, is now generally employed to the exclusion of the older types. The orders for this type of machine during the year called for over 200,000 h.p. output. Of the large air-blast transformers the year's orders aggregate 150,000 h.p. output.

Some Recent Electrical Patents.

A Means of Preventing the Wheels of Electric Cars from Slipping.—In the operation of electric locomotives having two, and especially those having four motors, it has been frequently observed that when the motors are connected in series with each other and one pair of wheels begins to slip, the motor driving these wheels immediately races, its counter e.m.f. rising and cutting down the impressed e.m.f. applied to the other motor or motors, and thus causing a decrease in the tractive effort. This is because the frictional grip of the wheels upon the rails diminishes greatly as soon as they begin to slip. The motor driving the slipping wheels therefore immediately runs right up in speed until its counter e.m.f. becomes nearly equal to the line e.m.f., cutting the current down to that which gives the motor a torque just sufficient to overcome the frictional resistance of the slipping wheels. This naturally cuts down the torque of all the other motors to the same value. In other words, when the motors are connected in series with each other, the slipping of one pair of wheels causes an immediate reduction of the torque upon all the wheels to as low a value as though they were all slipping. Mr. J. R. Cravath has patented a device for checking this slipping as soon as it starts, and has assigned the patent to the General Electric Company. The nature of the device is shown in the accompanying diagram, Fig. 1, in which T is the trolley delivering current to armature, M^1, and field, C, of one motor in series with armature, M^2, and field, D, of the other motor, the current passing thence to ground. The device consists of a electro-magnetic switch, shown in the upper part of the diagram. Normally, the switch is held by centralizing springs in the position shown, but if either motor as M^1, begins to slip, the e.m.f. across its brushes rises considerably above that across the brushes of the other motor, and the magnet, E, becomes stronger than F, drawing the switch to the left and closing a shunt through the resistance, R, around the field, C, of the slipping motor. This weakens the torque in this motor to a point sufficient to stop the slipping. In case the other motor slips, the switch operates in the opposite direction, shunting the field of the other motor. Patent No. 636,023.

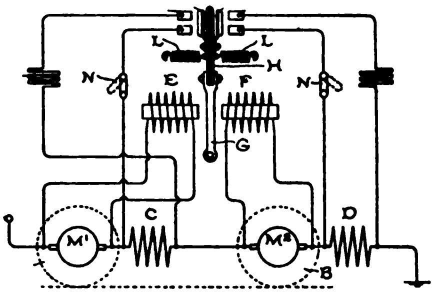


FIG. 1.—PATENT NO. 636.023.

Electric Power Transmissions Through the Air.—The plan of Mr. Nikola Tesla to transmit electric power over long distances by generating sufficiently high voltages to cause the currents to travel through the partial vacuum of the upper atmosphere, has been covered in a patent recently issued to the inventor. The plan proposes the use of balloons to elevate a conductor into the upper atmosphere at the transmitting and receiving points, the rarified atmosphere serving as a conductor in one direction between the elevated terminals, the ground serving as a return. The patent specifications state that extremely high tensions, such as those of hundreds of thousands or millions of volts with a frequency of several thousand per second, exhibit a tendency to discharge upward from the ground, tending to show that the terminals will not have to be elevated into the region of vacuum rarification. The patent further states that the low frequency of 1000 per second may be resorted to in order to operate motors of the ordinary kind. There is described an experimental apparatus delivering an e.m.f. of from 2,000,000 to 4,000,000 volts, a current under this pressure being carried through a vacuum tube with a length of 50 ft. and a barometric pressure varying from one-fifth to one-third of an atmosphere. The specifications conclude that many thousands of horse-power may be transmitted over hundreds or even thousands of miles with electromotive impulses not greatly exceeding 15,000,000 or 20,000,000, and with terminals supported by captive balloons at a height of not more than 20,000 to 35,000 ft. above sea level. The patent claims broadly the propagation or flow of electrical energy by conduction through the earth and air. Patent No. 645,576.

A Reverse-Current Circuit Breaker.—There has been used in England a form of alternating-current circuit breaker designed to open the line in case of a reversal of direction of the flow of power, and thus intended for the same purpose as the reverse-current circuit breakers described in the article on the Niagara system appearing in these columns in the issue of January, 1900. The English circuit breaker combines the magnetic devices, designed to distinguish between the flow of power in the two directions, with the circuit-breaking devices proper, making one instrument of the whole; whereas the American breakers of this type so far developed have been actuated by relays located, as a rule, at some distance from the circuit-opening parts. The United States patent for the English form has been issued to Mr. Leonard Andrews of Hastings, England, a diagrammatic sectional view from the patent drawings being reproduced in Fig. 2. In this view, 14 represents a handle mounted on the arm

15, pivoted at 16, and forced outwardly by a spring, not shown. A lug on the lower end of this arm strikes a pin which pulls out the switch contacts attached to the bolt, 7. The handle is retained in position by the hook, 18, engaging the arm, 21, the lower end of which latches over a pin mounted on the armature, 33, of a small bipolar electro-dynamometer. The rotable armature of this dynamometer is wound with a potential winding connected across the circuit, the field, 24, of this motor-type dynamometer being connected in series with the line to be protected. Normally the reaction between the shunt and series coils is such as to force upwardly the pin engaging the lower end of the arm, 21, but if the direction of the flow of power reverses, the armature of the dynamometer tends to rotate in the opposite direction, lowering the pin, releasing the arm, 21, which disengages the catch, 18, allowing the arm, 15, to fly out and break the circuit. The claims on this patent are very limited, so that it does not cover the types of apparatus used for the same purpose in this country. Patent 638,085.

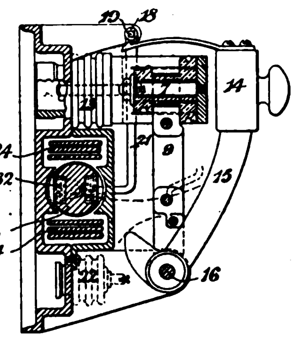


FIG. 2.—PATENT NO. 638,085.

A Means of Preventing Magnetic Unbalancing in Multipolar Dynamos.—To prevent inequality between the strengths of the various poles of direct-current multipolar machines with multipath armature windings, it is the custom of the Westinghouse Electric & Manufacturing Company to connect points of equal potential in the armature winding by internal cross-connecting rings. This remedy for unbalancing is inapplicable in the case of two-path direct or alternating-current machines, or open-coil alternators. To provide an equally effective remedy for these cases, Mr. B. G. Lamme has patented the use of a separate winding, laid in the same slots that carry the usual armature winding, or in others, and cross-connected in such a way as to allow the interchange of polyphase wattless currents to equalize the strength of the several poles. The arrangement is diagrammatically shown in Fig. 3, in which may be seen two rings at one end of the armature, each being connected to bars placed in slots spaced at a distance equal to twice the polar pitch from each other, the other ends of these bars being similarly cross-connected by two rings at the other end of the armature. This makes virtually a parallel-connected two-phase alternating-current winding, in which equalizing currents may flow for the purpose above mentioned. Patent No. 646,092.

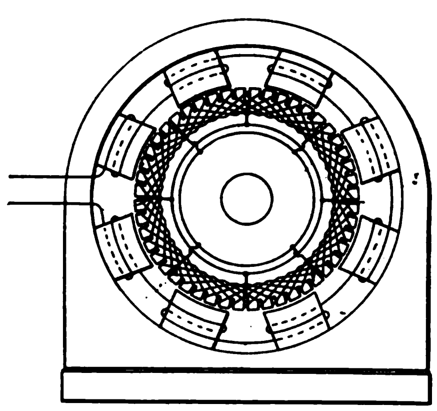


FIG. 3.—PATENT NO. 646,092.

An Arc Extinguishing Fuse Holder.—To prevent the violent explosion of a fuse in a high-tension circuit, Messrs. H. W. Smith and W. J. Baughman have incorporated several unusual devices in a fuse holder which has been placed on the market by the Stanley Electric & Manufacturing Company. One form of this fuse holder is shown in Fig. 4, the fuse passing through an insulating tube which serves as a handle, by means of which the holder can be removed from jaws or clips for re-fusing. Fuse A passes through the fiber enclosing tube, C, with an enlarged opening, E, at the end of this tube; this opening containing a carbon ball, F. When the fuse blows out this carbon ball is forced out to the outer opening of the chamber, where it acts as a stopper, giving a compression effect and preventing the flame from escaping. Over the end of the tube there is placed a metal plate, D, to cool and condense the metallic vapors, the same object being served by two perforated metallic diaphragms, J and J'. At the very top of the device there is a hinged lid, J², which is forced up when the fuse blows, giving an indication that the circuit has been opened by the action of the fuse. Patent No. 636,577.

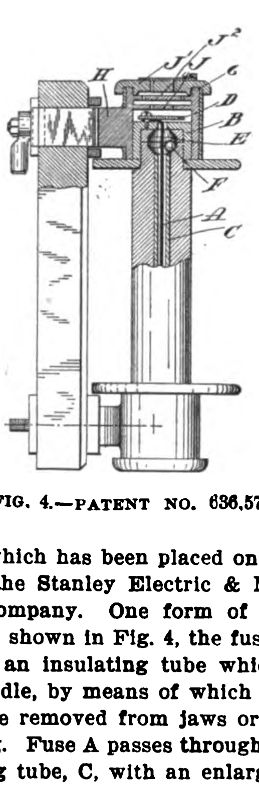


FIG. 4.—PATENT NO. 636,577.

NOTES.

Temperature of Incandescent Lamp Filaments.—In a recent communication to the Paris Academy of Sciences, M. Janet stated that the temperature of incandescent lamp filaments is in the neighborhood of 1600 to 1700° C. or 2900 to 3100° F. The temperatures were calculated on the assumption that the filament was composed of pure carbon.

The Duration of an Electric Spark.—In a communication to the French Academy of Sciences, Messrs. Abraham and Lemoine stated that a stroboscopic study of the electric spark had led to the conclusion that the total duration of the spark is less than 4/10,000,000 of a second, and that it attains its maximum brightness in about 1/100,000,000 of a second.

Electrolytic Nickel Plating.— A series of experiments were recently made at the University of Wisconsin in electrolytic nickel plating, and it was found that by using the ordinary plating solution and passing both alternating and direct currents through the vat there was a marked influence on the character of the deposit, it being possible by this means to obtain as thick a coating as desired.

Electricity in Gold Mining.—At a recent meeting of an English gold mining company it was reported that the company began its boring operations with steam power, but found that the wear and tear on machinery was so great that electric power was substituted. It was further reported that since the change the machinery had been working with the utmost satisfaction, and that the pumping and hoisting plants will be also changed over to electric power.

A Well Managed Lighting Plant.—The annual report of the municipal electric light plant of South Norwalk, Conn., which is managed by Mr. A. E. Winchester, shows that the total output for the fiscal year was 180,793 kilowatt-hours; the average income was 6.14 cents per kilowatt-hour; the average cost of production per kilowatt-hour, including interest and depreciation, was 5.79 cents and the average cost, excluding interest and depreciation, was 4.05 cents per kilowatt-hour.

A Proposed 40,000-H. P. Hydraulic and Electric Plant.— The Susquehanna Electric Power Company is contemplating the erection of a power house on the Susquehanna River in Maryland about three miles south of the Pennsylvania line for the purpose of converting the power of the river into electricity. It is proposed to put a dam across the river above the Pennsylania border line and construct an embankment from this dam to the power house, where the available head will be 40 ft. It is estimated that the normal flow of the river will give an output of 40,000 h. p. and that the development of the plant will cost $7,000,000.

Electric Lights on Locomotives. — The locomotive engines which handle the through coast trains of the Northern Pacific Railroad Company are being equipped with electric headlights, together with 8-c. p. incandescent lamps in front of the steam and water gauges, along the underside of the running-boards and beneath the boiler. The incandescent circuits are taken directly from the brushes of the small series-wound generator which supplies current for the headlight.

A Third-Rail Interurban Electric Railroad. — The Albany & Hudson Railway & Power Company has absorbed the old Kinderhook & Hudson steam railway and proposes to substitute for it a third-rail-electric railway power system. The system will include a line from Hudson to Albany, N. Y., passing through intermediate towns; within the limits of each town included in the route the overhead trolley system will be used, the third-rail system being proposed only in country districts.

Limit of Output for Individual Motors.— At a recent meeting of the American Society of Mechanical Engineers, Prof. J. P. Jackson stated that all machine tools requiring 5 h.p. or over should be driven by individual motors in order to secure maximum economy, and smaller machine tools should be grouped and driven from a common line shaft, the groups being so arranged that not less than 5 h.p. or more than 15 h.p. would be required to drive the shaft. As an example, Prof. Jackson cited the practice at the Baldwin Locomotive Works, where no motor smaller than 5 h.p. is used.

Electrical Equipment for an English Lighthouse.—The lighthouse on the island at the mouth of Firth of Clyde has been fully equipped with electrical apparatus. Not only is the light furnished by an arc lamp, but the lens chariot, or turret, is revolved by an electric motor and an electrically-driven pump is used to transfer oil from boats to the lighthouse. The oil is used as a fuel in oil engines which drive four dynamos supplying the current for the operation of the lighthouse apparatus. Pumps for supplying air to a siren fog signal are also provided, but these are arranged to be driven by any one of the oil engines.

A Peculiar Dynamotor. — A dynamotor for use in charging storage batteries was recently designed by Messrs. Legros & Meynier, which embodies the very unusual feature of the old Siemens "shuttle" armature winding. One of the armature windings is of the usual drum type, connected in the conventional manner with its commutator. The second winding is of the shuttle type, consisting of a single large coil of wire connected to a two-part commutator exactly as was the case with the old Siemens winding. Another peculiar feature is the claim made by the designers to the effect that the use of the shuttle winding reduces considerably the weight of the dynamotor.

Another Power Transmission Plant for Colorado.—A power transmission line is projected between Beaver Creek Colo., and the works of the Gold Coin Mining & Leasing Company in the Cripple Creek district. It is proposed to put in two power plants, the one being situated at a point where the hydraulic head is 1150 ft. and the other being located at a point lower down, the total head being 2300 ft. from the reservoir to the lower plant. The surface distance from the reservoir to the lower plant is about 6000 ft., and the water supply is said to be sufficient to develop 5000 h. p. The upper plant, which will work under the initial head of 1150 ft., is now in course of construction. The equipment consists of four 375-kw. General Electric alternators, each direct-driven by a pair of 69-in. Pelton water-wheels, running at 450 r. p. m. The wheels and generators will be mounted on separate bases and their shafts connected by means of combination fly-wheel couplings.

Leakage from High-Voltage Transmission Lines.—Mr. Budd Frankenfeld, in a paper read before the Chicago Electrical Association recently, pointed out that although a three-phase circuit is more economical than either a single-phase or two-phase line when considered solely in the light of ohmic drop, this is not true when the working limit of voltage is approached, on account of leakage. The two-phase four-wire system interconnected has six leakage paths, two at the limit of pressures and four at 70.7 per cent. of this pressure; the three-phase system has three leakage paths, each at the limit of pressure; the two-phase four-wire system with independent circuits has only two leakage paths, both at the limit of voltage, with the single-phase system has only one path, that at the limit of voltage. Considering the various systems under this condition, the single-phase circuit shows the greatest advantage, the two-phase system with independent circuits coming next and the two-phase interconnected and three-phase systems being the worst and differing little from each other.

A New Internal Combustion Engine.—In the presidential address of Mr. Henry O'Connor, to the Society of Engineers, London, a new internal-combustion engine devised by a Mr. MacCallum was described. The chief feature of novelty is the use of coal dust burned in the working cylinder as proposed by Mr. Diesel. The cycle of engine consists of drawing in a charge of air, compressing this charge just as the charge of an ordinary gas engine is compressed, injecting the proper quantity of coal dust onto a wrought-iron plate attached to the piston, the usual working stroke following the ignition of the coal dust. At the end of the power stroke the exhaust valve opens, allowing the combustion products and suspended ash to escape. The claim is made that the fuel never comes into contact with moist surfaces, being injected directly onto the hot plate attached to the piston, and is always kept in a state of suspension and motion, so that no accumulation of ash or dirt takes place within the engine, the force of exhaust being sufficient to sweep out any extraneous matter which may enter with the fuel. An experimental engine, tested in Edinburgh, is said to have given excellent diagrams and to have shown a fuel consumption of about 1½ lbs. of coal dust per horse-power hour. The engine tested developed 15 h. p. at a speed of 150 r. p. m. It was predicted by engineers who witnessed the test that an improved engine of larger size could obviously be constructed to give a coal consumption of about ½ lb. per horse-power hour. In the experimental engine tested, which was naturally defective in several points, nearly half of the total amount of fuel injected was exhausted without having done any useful work. It is said that almost any kind of coal can be used; the coal must, of course, be pulverized before using. The details of cylinder lubrication are not given.

Machinery and Transportation Building at the Pan-American Exposition—One of the big buildings of the exposition to be held next year at Buffalo will be that devoted to machinery and transportation. It will be 500 ft. x 350 ft., with a central court 100 ft. x 175 ft. Its location is on the west side of the main group, opposite the Court of the Fountains. The architectural style is that of the Spanish Renaissance, modified to suit the conditions of the exposition. The work is more ornate, however, the roofs being laid with red tile and the cemented walls brilliant with color. The colors are to be reds and yellows in light tints. The facades will present an arcaded effect, with broad overhanging eaves, in imitation of the old mission buildings in California and Mexico. Each facade will be broken by an important architectural feature, and each corner flanked with low pavilions, the design giving large plain surfaces for color, while the eaves give deep shadows. The loggias, balconies, pavilions and other places are to be ornamented with shrubs, vines and flowers, blending with the coloring of the building. The openings are grilled with specimens of wrought-iron "Rejas" or grill screens, such as are seen in examples of Spanish architecture of the sixteenth century.

The building has numerous entrances, the principal ones being in the center of each of the four facades. From the inside of the structure the size can be better appreciated. All the towers, pavilions and other proper spaces are to be brilliantly illuminated and made gay with banners and flags. The central court will be a veritable tropical garden, with a long narrow pool containing interesting specimens of aquatic life, and will have winding paths and seats among the flowers and shrubbery, where the weary visitor may find rest and diversion from his study of the more practical features of the exposition.

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Isolated Central Stations.

The great increase in the number of electric lighting and power plants in huge industrial establishments, such as that which forms the subject of our leading article this month, has resulted in the creation of a virtually distinct class of installations for which there is no specfic name. In former years, when a 500-light incandescent lighting isolated plant commanded a considerable degree of respect, the dynamo was put in a secluded corner, out of harm's way, and received occasional attention whenever the engineer or some engine-room habitue chanced to remember its existence. The term "isolated plant" has become so thoroughly familiar as applying to equipment of this sort that, notwithstanding the entire absence of implication as to size, the expression naturally suggests a small outfit of an incidental character, not a plant organized and operated on the lines of a respectable central station. It seems somewhat incongruous to apply the same term to both. Commercially, installations like those at the Armour place and the Waldorf-Astoria Hotel, are isolated plants; electrically, they are central stations. But the term "isolated central station" is somewhat anomalous if not solecistical.

One of the features of the Armour plant that will doubtless incite criticism from advocates of uni-type generators is the employment of alternators for lighting service and direct-current generators for power. As each engine drives two generators, one of each type, the only disadvantage apparently is the extra cost of installation involved. The cost of operation is not appreciably increased (unless by interest charges), nor is the liability to break-down; neither is there any great sacrifice of interchangeability. Shutting down an engine means simply withdrawing the capacity of that engine, which would be the case if the engine drove a single generator of either type. The working difference in favor of a single machine obviously is the greater simplicity; on the other hand, the use of both types of generator provides better regulation at the motors and vastly better circuit regulation at the switchboard. Taken all in all, the plan which has been adopted is a rather commendable compromise between the two extremes of different generator types driven by separate engines and one type of generator supplying current for both lighting and power service.

Motor Speed Control.

An interesting discussion of methods of speed control applicable to motors doing special service appears in another part of the paper, and constitutes a fairly complete review of the fundamental principles underlying all of the practical systems now in use. A very few years ago the control of constant-potential motor speed, excepting electric railways, was obtained solely by means of a rheostat in series with the armature; as a result of this the use of electric motors for driving large printing presses was extremely rare, and where an instance existed the results were anything but satisfactory. The demand for an individual electric drive which would give the desired degree of control and economy rapidly developed this branch of the motor industry until now one has a choice of any one of several entirely practical and efficient plans, as outlined in the articles mentioned.

Upon the character of the work depends, naturally, the method of speed control. In service involving frequent starting and stopping, and running at any one of several speeds, as in the case of machine tools, the preferable method of regulation is doubtless the provision of multi-voltage service for the motor armature, combined possibly with variation of the counter e.m.f. of the armature per revolution. Multi-voltage supply may be provided in any one of three ways: The generator armature may have two windings and commutators; a motor-balancer arrangement may be used to maintain the divisions of e.m.f. or a storage battery may be employed for this purpose. Both of the last mentioned methods are described in Mr. Mather's article. The counter e.m.f. of the motor armature may be varied either by providing two windings and commutators and connecting them in series or parallel, as described by Mr. Adams, or by varying the field strength of the motor, as described by Mr. a' Becket. Thus there are available twelve combinations, each giving a large number of running speeds, excepting the ordinary single voltage supply with double armature windings, which affords only two working speeds.

For printing-office service, a simplification of one of the systems described by Mr. Mather appears to be ideal; that is, the provision of a three-wire circuit dividing the full e.m.f. into one very low voltage and the other near the maximum, and maintaining the division by means of a motor balancer. For example, if the generator gives 230 volts, the motor balancer would be designed to maintain, say, 15 volts between the middle wire and one outer wire, and 215 volts on the other side of the middle wire. For "making ready," the motor armature would be connected across the 15-volt circuit; for ordinary printing it would take the maximum of 230 volts, and for a finer grade of press work it would take current from the 215-volt wires. The same results obviously might be obtained at slightly better efficiency by employing two windings on the generator armature instead of a motor balancer. Small variations from the fixed speeds thus secured might readily be obtained by adjusting the excitation of the motor field magnet.

In machine-shop practice, where individual motors are employed, the foregoing plan as outlined would not be available. All machine tools have three-cone pulleys, and large ones more, and the speed intervals are more uniform than in the case of printing presses. For this class of service, therefore, if three-wire multi-voltage supply were employed, the e.m.f. on one side of the middle wire would be something like one-third of the total, so that the running speeds would be one-third of the maximum, two-thirds and maximum. For four-speed tools the preference would probably lie between an equally-divided three-wire multi-voltage supply with double-commutator motors, and simple motors supplied from four-wire multi-voltage circuits. In any case, of course, local conditions will largely determine the method of control to be used.

Live-Steam Feed-Water Heaters.

The important fact that the boiler feed-water may be heated economically in many cases by means of live steam, as pointed out by Prof. Durand in another column, seems to have been not generally understood, or else it has not received the proper consideration. One of the most perplexing problems in the design of central station power plants, where free condensing water is available, is the supply of heat for the feed water in case the plant is to run condensing. There is a mental wrestle as to the employment of economizers, heaters between the engines and the condensers, heaters utilizing the exhaust from auxiliaries, and the elimination of exhaust heaters by the use of belted or motor-driven auxiliaries. And after having decided upon the arrangement to be used in case condensation is employed, it remains to make a comparison with the results obtainable by running non-condensing or partly so, and heating the feed water entirely by exhaust steam.

The practicability of using live steam to heat the boiler feed water might appear to add to the complexity of the matter, but in reality it tends to simplification for the reason that the question of running non-condensing is, in most cases, eliminated. Of course the specific conditions of operation are controlling factors. It cannot be broadly stated that heating the boiler feed water by means of live steam is good practice under all circumstances. But the fact that it is an economical expedient under a surprising range of conditions is of immense importance, and should by no means be ignored or overlooked when the arrangement of a steam plant where condensing is commercially feasible is under consideration.

Equipment for Small Central Stations.

A problem that puzzles not only middle-grade central station managers, but experienced constructing engineers (who are not blindly prejudiced) is the determination of the character of electrical equipment for small central stations. Such stations commonly furnish the three usual classes of service—arc lights, incandescents and motors. If the radius of service be small and the distribution compact, it is perfectly obvious that a 250-volt three-wire direct-current system will be adequate. But this case, so readily disposed of, is one of the rarest that is found in practice. It is safe to say that nine-tenths of the small plants, supplying something like 40 to 75 arc lamps for street lighting, will have to provide a most erratic distribution for incandescent lamps and motors.

The most frequent case is that in which the distances are so great as to dictate the use of alternating current for incandescent service, and either alternating current or 500-volt direct-current service for motors, while the consumers are so scattered and the individual demand so small as to render the expense of delivering the service abnormal and the disadvantages considerable. Alternating-current advocates claim all the virtues in the category for a purely alternating-current system including arc lighting and motors; direct-current champions declaim enthusiastically on the subjects of unity power factor, quietness and high efficiency of direct-current arc lamps and the ease with which the speed of direct-current motors may be controlled.

The impartial engineer fills his weary brain with considerations of the flexibility and inefficiency of underloaded and small transformers; the mechanical simplicity of induction motors and their comparatively inflexible speed control; the high efficiency of direct-current arc lamps and the awkwardness of supplying current for them at a distance—and frankly owns that he doesn't know just what is best. Unless he has unusually good judgment, the result is generally an unsatisfactory mongrel sort of a plant. Beginning with the next issue we shall present a series of articles dealing with this problem.

Th Future of the Horse.

When the good old stage coach was inconsiderately relegated to oblivion by the locomotive there was a variegated protest from numerous perverse or misguided persons, who manifested an entirely gratuitous solicitude for the safety of the public and the preservation of the equine species. A kindred class of philozoists embraced the welcome opportunity for notoriety upon the advent of the bicycle, and when electric railway equipments proceeded to displace dilapidated apologies for vehicles and the specimens of decrepit animal life(?) that drew them, the same old wail was emitted with a few variations. There arose the ubiquitous calamity prophet, who delivered mournful predictions relative to the immediate extinction of "that noble beast of burden, the horse;" denunciations of the ingratitude of selfish mankind, and other borrowed and garbled platitudes. And when the automobile became a melancholy reality the woe of these morbid fanatics was like unto that of Rachel.

At a sale of horses held recently, a bay gelding brought $7,800, and other horses, probably as good or better, sold for sums ranging between $800 and $1,500 each. Verily, this sale and others like it which have occurred from time to time must have dealt severe wrenches to the theories of the pessimistic class referred to above. There is no record of any attempt on the part of these people to reconcile the repeated manifestations of high-priced interest in the poor doomed horse with their own forebodings, blindly reiterated at every stage of vehicular progress; they have at least sufficient wisdom to refrain from such an attempt. If there is any connection between the frequent sales of horses and the future fate of the species, the prices realized certainly indicate anything but the impending classification of the horse with the megalotherium.

DESIGNS FOR COMBINED ALTERNATING AND DIRECT-CURRENT GENERATORS.—III.

FOUR-KILOWATT MACHINE.

BY J. C. BROCKSMITH, M. E.

The machine here illustrated is the largest of the machines of the same general type of which this is the third to be described in these columns. The present machines has 8 poles; its speed is from 1800 to 1875 r. p. m., and it has an output capacity of four kw.

Fig. 1 shows an end view of the field, base, and bearing pedestals. The field has a circular yoke of cast-iron with pole-pieces of laminated wrought iron cast in. About No. 20 gauge iron may be used in the poles and they are bored out to 5 9/16 ins. diameter after being cast in. Fig. 2 is a section of the assembled machine, which shows the construction and relation of the various parts. The armature core is built up of soft iron discs about No. 27 gauge, having an external diameter of 5½ ins., with a 2½-in. hole in the center. The discs are mounted upon three-arm spiders, one at either end of the core, and the arms of which intermesh about ½ in. at the center of the core, so that all the discs are supported at least three points, and at the same time the air has free access to the interior of the core. Distance pieces are provided at two points in the core which divide the laminations into three groups with 3/16-in. ventilating ducts between them. Two hexagonal nuts upon the shaft provide means for clamping the core discs and spiders.

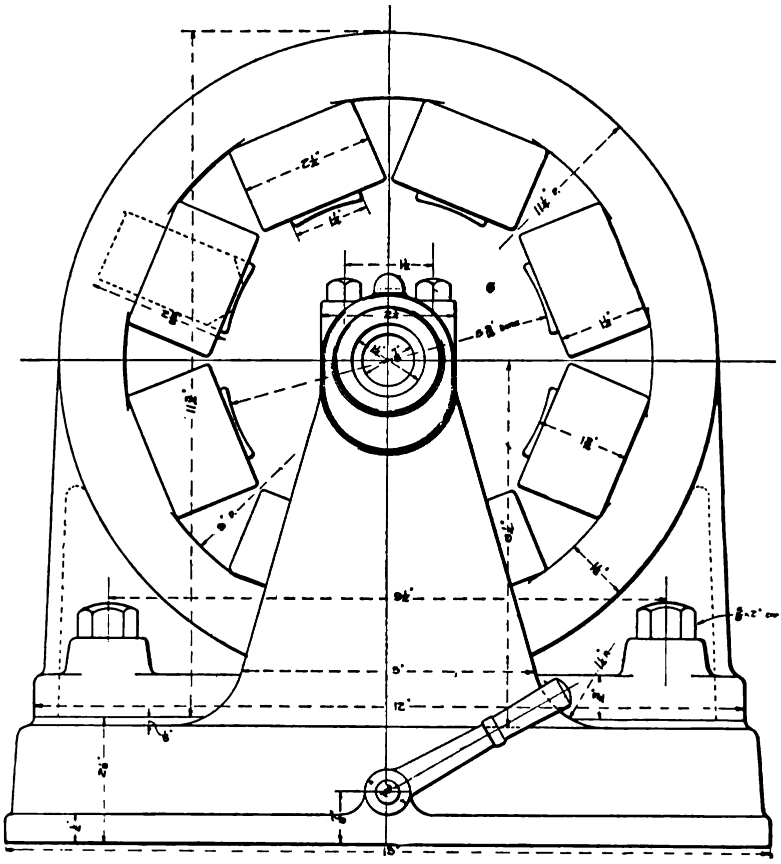

FIG. 1.—END ELEVATION OF FIELD MAGNET

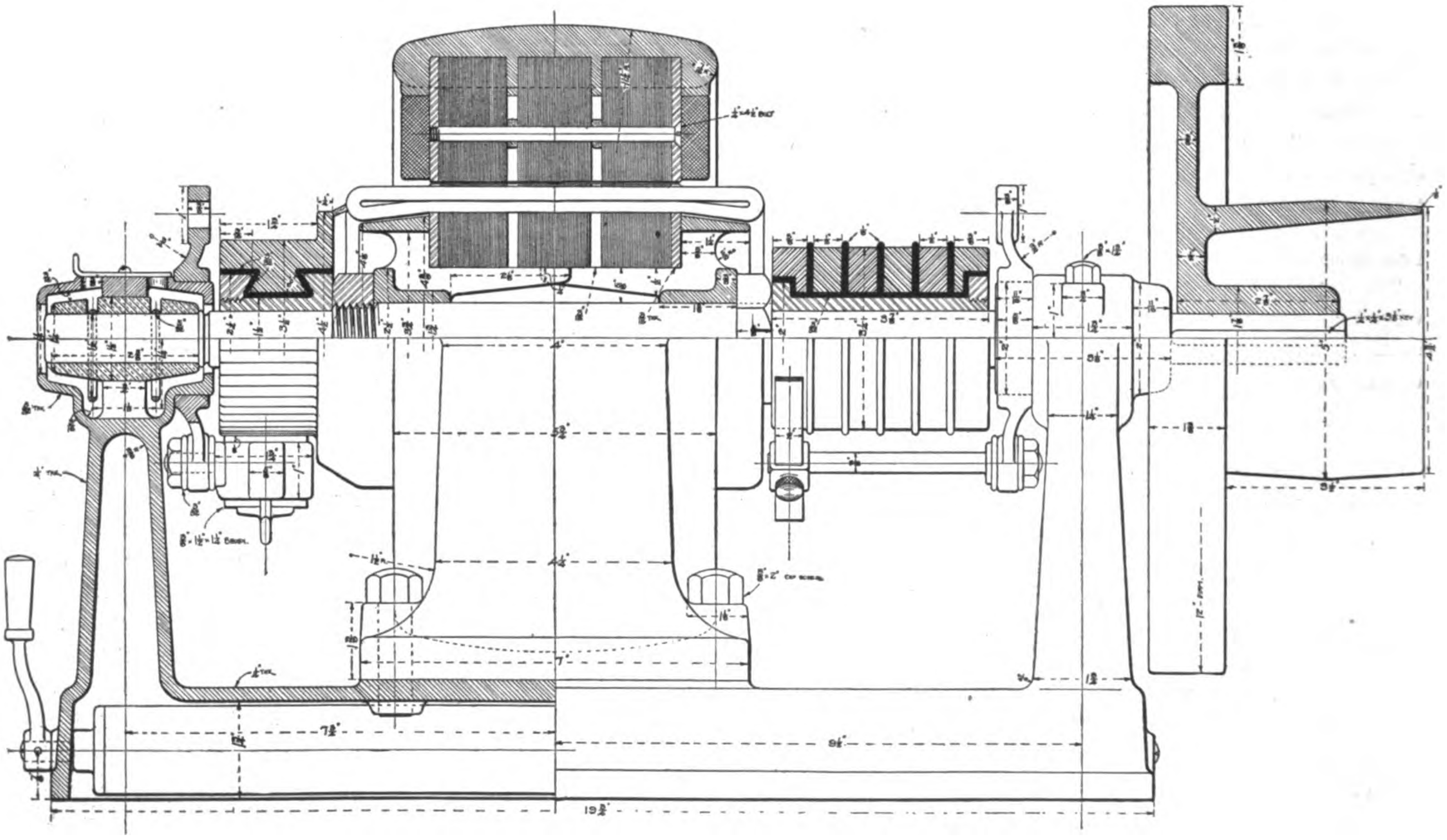

FIG. 2.—LONGITUDINAL ELEVATION OF COMPLETE MACHINE. ONE-HALF IN CROSS-SECTION.

The commutator, which is shown partly in section, is 3½ ins. in diameter and 1¾ in. wide on the face. There are 48 segments of copper with 3½-in. mica between them, and 3/32-in. insulation separates the segments from their supporting sleeve. The sleeve is of machine steel and has flanges undercut at an angle of 60 deg. The collector rings are six in number and are made of copper. The rings at the ends are ⅝-in. wide; the rest are ½ in.; ⅛-in. insulation separates the rings from each other. The bearings have a brass sleeve fitting the shaft, and this is slotted to allow oil rings 5/32 in. wide to revolve freely with the shaft.

At the alternating-current end of the machine the fly-wheel pulley is shown in position upon the shaft. A pulley of this kind will be found very useful in operating the machine as a rotary or in connection with a gas engine for driving, as it assists the armature in maintaining a uniform rate of rotation.

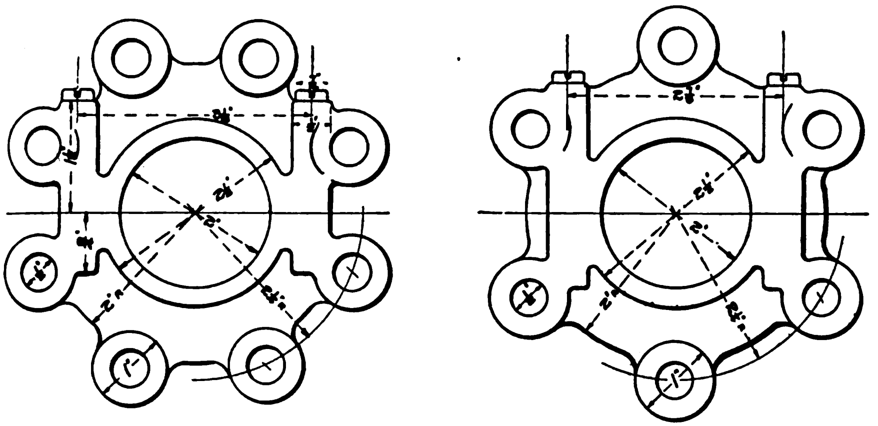

FIG. 3.—BRUSH HOLDER COLLARS.

Fig. 3 shows the rocker arms for the alternating-current and direct-current ends of the machine. The one at the direct-current end has eight lugs for supporting the eight brush holders and the alternating-current end has six, one for each of the six rings. Both are made in halves and screwed together after being placed in position on the bearings.

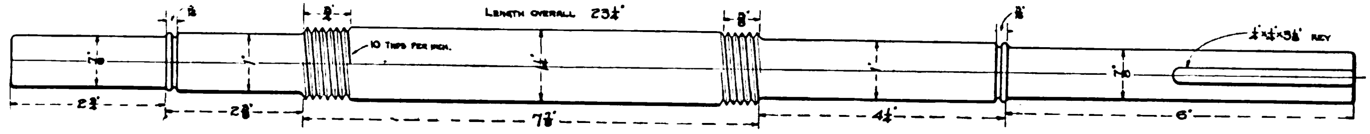

FIG. 4.—THE SHAFT.

Fig. 4 is a detail of the armature shaft. This is designed to be made from a piece of 1¼-in. cold-rolled steel. Threads are cut at both ends of the core portion to receive the hexagonal nuts which compress the core discs.

Fig. 5 shows details of the direct-current and alternating-current brush holders. The direct-current holders are for radial brushes ⅜ in. thick, 1½ ins. wide and 1¼ ins. long, and are provided with a spring tension arrangement, the details of which are shown in the engraving. The alternating-current brush holders are for copper leaf brushes ⅛ in. thick and ½ in. wide; the spring of the brush itself will be found sufficient to give proper contact with the collector rings. The studs which support these holders are of different lengths to suit the position of the various collector rings. The dimension marked "x" on the drawings has the values 3⅞ ins., 3¼ ins., 2⅝ ins., 2 ins., 1⅜ ins. and ¾ in. for the six studs respectively. They are best made of ⅜-in. brass rod.

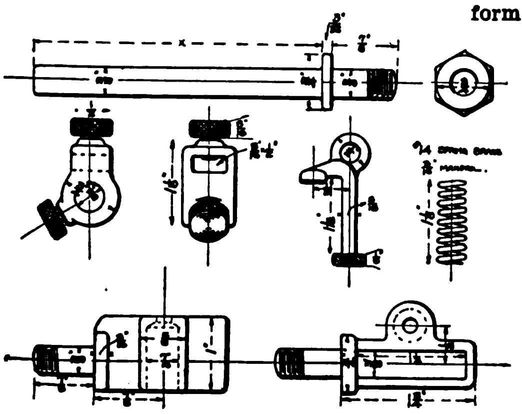

FIG. 5.—DETAILS OF BRUSH HOLDERS.

Fig. 6 shows an end view of the armature core. There are 48 slots, 3/16 in. wide and ½ in. deep. If these slots are milled out, it will be necessary to take the discs apart after this operation in order to anneal and insulate them before the final assembling. Annealing will improve the discs, which will have become somewhat hardened from the machine work which has been done upon them.

Fig. 7 shows a development of the armature winding. This is of the "straight out" type and is of two forms, designated as the "long coil" and "short coil." The long coil is for use in a four-pole field and for 60-cycle work. The short coil is for eight poles and 125 cycles. These coils are form wound of No. 17 double-cotton-covered wire, 12 turns per coil. The terminals of each coil are brought out at its apex, and are connected to the two nearest commutator segments, inside terminal of one coil and the outside terminal of the adjacent coil connecting to the same segment. This will bring the neutral point or line of commutation at or near the center of the pole-pieces.

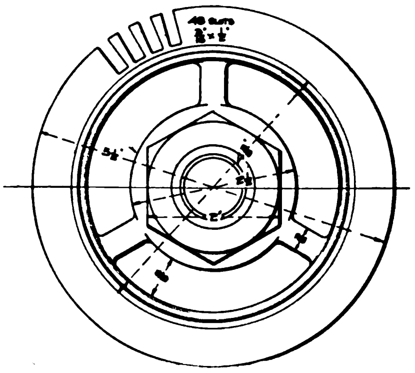

FIG. 6.—END OF ARMATURE CORE.

Figs. 8 and 9 are diagrams to guide in making taps to the collector rings. The eight-pole arrangement is intended for operating on 125-cycle circuits, and the four-pole for 60-cycle circuits. The necessary interconnections between segments may be made at the back of the commutator before it is placed in position on the shaft. For instance, in the eight-pole arrangement, segments 1, 13, 25 and 37 are connected together and to a lead marked No. 1. The leads numbered 1 to 6 inclusive pass through the air space in the center of the core and connect to the corresponding rings. Thus connected, single-phase current may be obtained from rings 1—2 or 3—4; two-phase currents from 1—2 and 3—4, and three-phase currents from 1—5—6. The outputs and voltages are as follows:

	Amperes.		Voltage.
Direct current..............	35		115
Single-phase alternating.	35		80
Two-phase alternating...	25	per phase	80
Three-phase alternating.	21	" "	70

Fig. 10 shows the details of the switch cylinder and contacts which are located in the base of the machine and serve as a starting device for operating on single-phase circuits.

A strip of fiber 19 ins. long, 1 in. wide and ⅜ in. thick is fastened to the under side of the cast-iron base and upon this are mounted 38 contact springs, each ⅜ in. wide. The cylinder is of hardwood 1½ ins. in diameter, and is of the proper length to just go inside the base and have its ends journaled therein. The free ends of the contact springs press upon the

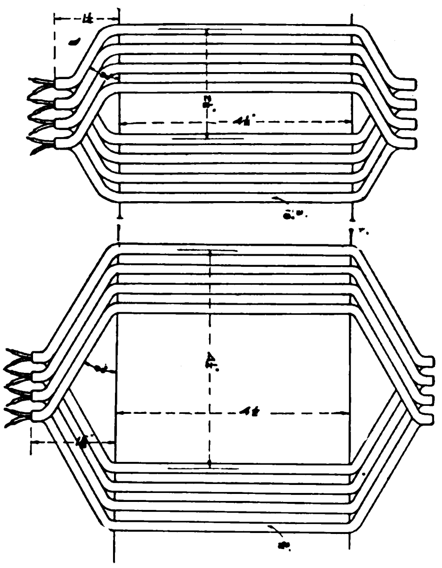

FIG. 7.—DEVELOPMENT OF WINDINGS.

cylinder and make connection with the contacts fastened upon the cylinder, but they can only be in connection with one row at a time. Fig. 11 is an end view showing details.

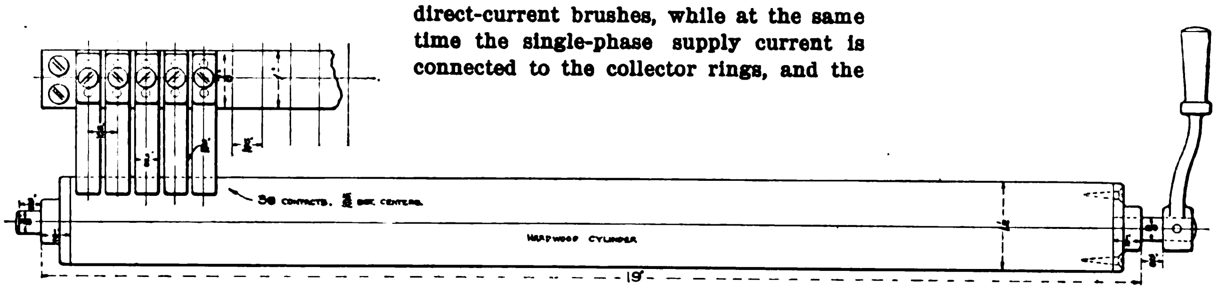

FIG. 10.—SHOWING CONTROLLER CYLINDER AND FIVE OF THE CONTACT FINGERS.

The diagram, Fig. 12, shows how the connections are made to the switch contacts. The uppermost row of small circles indicates the contact springs to which the sectional field winding is connected. There are eight coils of two sections each, making 16 pairs of terminals to be connected to the switch. The remaining three pairs of contacts connect with the direct-current brush leads, alternating-current rings, and single-phase mains in the manner indicated. The lower two rows of circles represent the contact pieces upon the revolving switch cylinder, these being simply connected in groups by means of short wires or metal strips fastened upon the cylinder itself and occupying that position of the cylinder over which the contact springs are not required to pass.

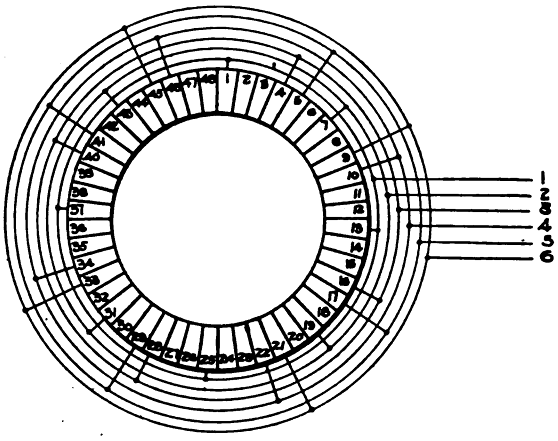

FIG. 8.—EIGHT-POLE CONNECTIONS.

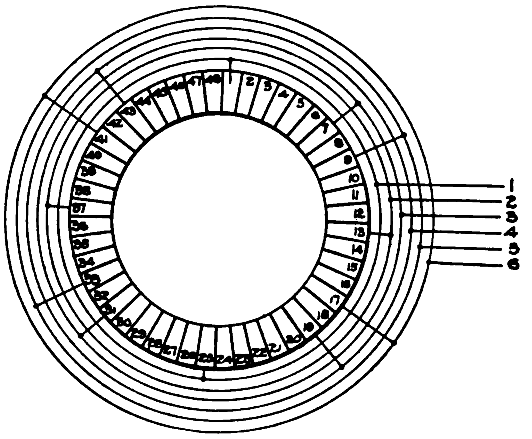

FIG 9.—FOUR-POLE CONNECTIONS.

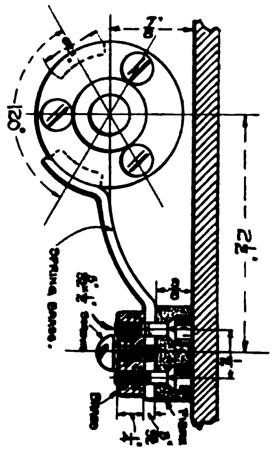

FIG. 11.—DETAIL OF CONTROLLER.

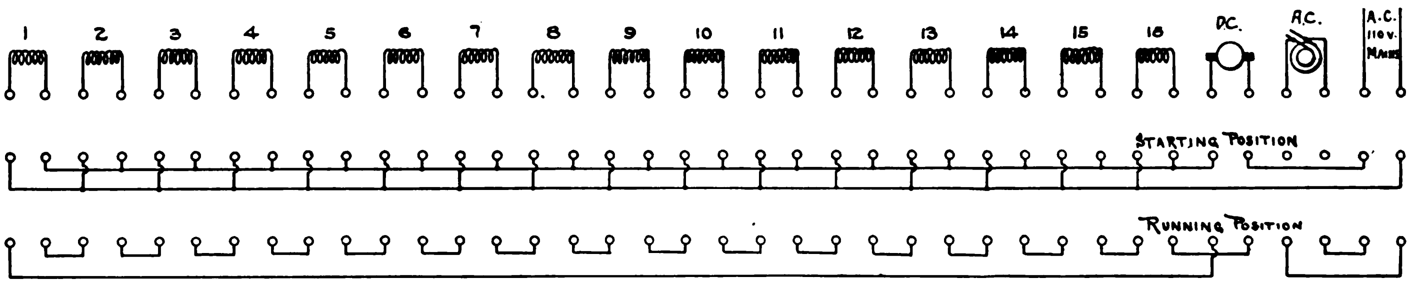

FIG. 12.—CONTROLLER CONNECTIONS.

The action of this device may readily be followed by assuming that the "starting" row of contacts has been moved up to engage the contact springs when it will be seen that all the field sections are in multiple, the armature in series with them, and the whole placed across the single-phase alternating-current mains, so that the machine starts as a series motor. When the second row of contacts engages the contact springs the field sections will be in series and placed in shunt across the direct-current brushes, while at the same time the single-phase supply current is connected to the collector rings, and the machine is now operating as a synchronous motor, exciting its field from the direct-current end, which is the normal running condition.

To operate the machine at 110 volts direct current or 125-cycle alternating-current no changes are necessary and the speed will be 1875 r. p. m. For 60-cycle alternating current work the number of poles is halved by reversing the terminals of any two successive field coils, skipping two coils and reversing the next two. This being most conveniently done by changing the connections at the starting switch. This change, together with the "long coil" winding and the diagram of connections for four poles fits the machine for operating at 60 cycles. The speed will now be 1800 r. p. m. and the voltage and output practically the same as before.

The following is a brief summary of the general dimensions and data for winding:

Eight-pole machine: 1800 r. p. m. at 60 cycles; 1875 r. p. m. at 125 cycles. Armature 5½ ins. diameter, 4 ins. long, 48 slots 3/16 in. x ½ in.; 3/16 in. = 188 in. width of slot, allowing three No. 17 wires and insulation of 18 milo; 5 in. depth slot, taking eight No. 17 wires and insulation and bands of 45 milo., giving 24 conductors per slot. Total, 1,152 conductors. Direct-current output at 470 circ. mils per ampere = 36 amps.

There will be 455 ampere-turns in each field coil.

Part.	Material.	Total lines.	Cross-section.	B.	H.	L.	Ampere turns.
1 armature	Wrought iron.	170,000	4. in.	42,500	4	1.5	6
2 air gaps	Air.	340,000	6.	56,600	17,880	.0313	566
5 teeth	Wrought iron.	340,000	3.	113,000	108	.5	54
2 cores	Wrought iron.	420,000	5.	85,000	18	1.7	31
1 yoke	Cast iron.	210,000	4.7	42,000	68	3.7	252
Total ampere-turns							909

Mean length of 1 turn = 13.5 inches, circ. mils shunt wire =

$$\frac{11 \times 13.5 \times 455}{12 \times 12} = 465.$$

Use No. 23, having 509 circ. mils, .034 in. diam., d. c. c.; 620 turns (approx.) per coil, in 14 lays, 44 wide turns. Wind in two sections and bring out individual terminals from each section.

Resistance of shunt field =

$$\frac{8 \times 620 \times 13.5 \times 20.3}{1000 \times 12} = 114 \text{ ohms.}$$

Normal shunt current $= \frac{450}{620} = .75$ amp.

Use rheostat of about 40 ohms in shunt field. Weight of wire in shunt coils:

$$\frac{8 \times 620 \times 13.5 \times 1.54}{1000 \times 12} = 8.5 \text{ lbs.}$$

Total length of wire on armature:

$$\frac{48 \times 18 \times 12}{12} = 864 \text{ feet.}$$

Total weight of wire on armature:

$$\frac{864 \times 6.2}{1000} = 5.37 \text{ lbs.}$$

Resistance of armature:

$$\frac{864 \times 5.04}{1000 \times 64} = .068 \text{ ohms.}$$

Drop in armature at full load:

$$36 \times .068 = 2.45 \text{ volts.}$$

◆

PHOTOMETRY FOR CENTRAL STATIONS.

BY LYMAN C. REED.

The measurement of light offers many difficulties not encountered in the measurement of such quantities as time and weight. The candle is the unit to which light intensities are referred. The origin of this unit was quite natural, as the candle was one of the earliest and most uniform of light-giving sources.

But this unit, while approximately constant, is subject to considerable variation, according to the size of wick, quality of the fuel, and height of the flame, besides the influences of atmospheric conditions. The standard English candle is supposed to give unit light with a flame 1.8 inch high, and a consumption of 120 grains of material, spermaceti and wick, per hour. The difficulties of obtaining a correct reading from such a standard are great and have led to the seeking of various standards, all of which are open to more or less objection. Some of the best known of these may be briefly mentioned without going into a detailed description.

The pentane lamp has many excellent qualities. Pentane is a refined distillate of gasolene, and in its pure state is an excellent fuel for a standard light-giving source. The difficulty of obtaining it in a pure state is so great that it has been practically abandoned as a standard. The pentane is fed by a wick to the flame, which burns inside a metallic chimney having a slit and a gauge for indicating the height of the flame.

The Methven screen arrangement, one of the well-known secondary standards, consists of an argand gas flame burning inside the usual glass chimney. On the outside of the chimney there is placed a metallic screen with a slit which allows a light intensity of two candles to pass. The flame burns at a height of three inches. The varying quality of the gas is the greatest objection to this light as a primary standard, although it may answer very successfully as a secondary standard.

The Hefner-Alteneck lamp, burning pure amyl-acetate, fulfills more fully the requirements of a reliable standard than any other known standard, and has been adopted provisionally by the American Institute of Electrical Engineers as being the best candle-power standard yet obtained. For a more detailed description of this and the other standards, the writer takes pleasure in referring the reader to a series of articles by Prof. Wilbur M. Stine, in the March, April and May (1899) issues of this paper.

Our appreciation of the intensity of light is at present confined to one organ, the human eye, and as every eye has its own particular "personal equation," the comparison of light intensities with any standard must vary by an appreciable per cent. according to the observer. Hence, when we speak of the "candle-power" of any source of light, it is more or less a comparative term.

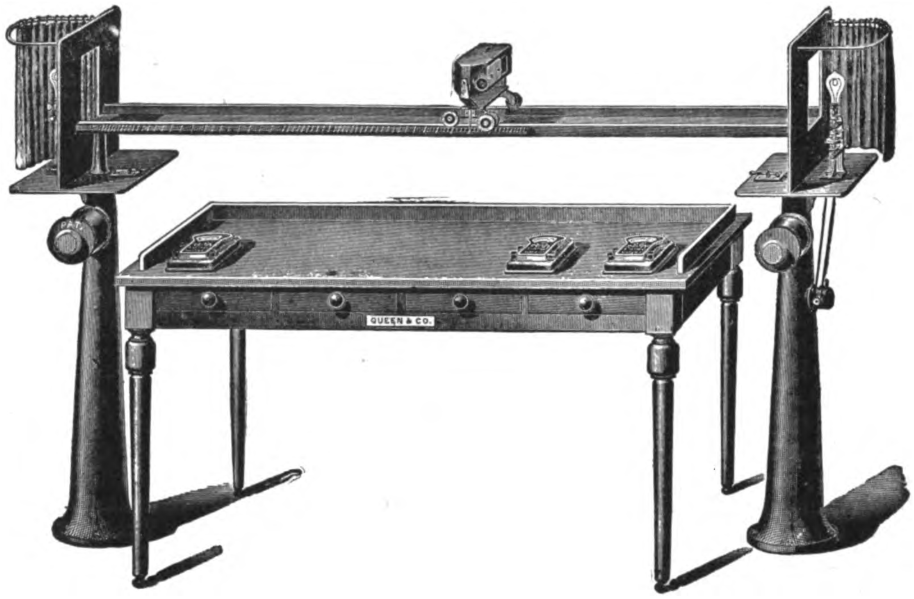

FIG. 1.—QUEEN STANDARD PHOTOMETER.

There are, then, two sources of error to contend with in the measurement of light, a variable standard and the personal error of the observer. In spite of these difficulties the commercial measurement of various light sources has reached a stage where the error amounts to but a few per cent.

A few years ago we rarely heard the word photometer outside of a laboratory. The advent of the incandescent lamp has been the cause of the familiarization of this instrument. There was little need commercially to measure the candle-power of a gas or oil flame; the light-giving qualities of the one are fixed by the size of the orifice of the burner, quality and pressure of the gas; those of the latter, principally by its size and the condition of the wick. The deterioration of the candle-power of a gas flame is dependent primarily on the source of supply, while that of the incandescent lamp, assuming the voltage constant, depends upon its age. This drop in illuminating power, due to ageing, it has been the chief desire of manufacturers to overcome. Their degree of success will be brought out more fully later. It is apparent that if the modern incandescent lamp remained of a constant light-giving quality, the factory test would be all that was needed to establish its candle-power until it was burnt out, and that the deterioration of the candle-power with age is the chief cause of the development of the commercial photometer.

An incandescent lamp of low efficiency can be made, however, which, when properly aged, will remain practically constant in candle-power if burned at the proper voltage. Such lamps are tested by a primary standard in a very careful manner and can then be used as secondary standards with a fair degree of accuracy; hence the use of oil and gas flames as secondary standards has given place to a properly aged and tested incandescent lamp. This practice has many advantages besides ease of manipulation in testing, the chief of which are slow deterioration of the standard and the same character of light as the lamp to be tested.

The commercial photometer with an incandescent standard is very simple and lends itself readily to the unskilled handling which it frequently encounters. Two excellent types of photometers designed for the commercial testing of lamps are the Queen Standard photometer and the Deshler-McAllister instrument, both well suited to the needs of the central station. Both of these photometers were designed to supply the need for a rapid and fairly accurate instrument. In photometers of this class the time element of a lamp test is the most important mechanical factor connected with the instrument, affecting directly also its value as a commercial success.

The Queen Standard photometer, which

is represented by Fig. 1, consists of two cast-iron pedestals carrying a rack on which are mounted the photometer carriage and scale. The carriage is rolled to any desired position and the reading taken directly from the scale. Two styles of screens are used, the Lummer-Brodhun and Bunsen. The former is about three to four times more sensitive than the Bunsen, but the latter may be read more quickly. Either may be used, but when the number of lamps to be tested is very large, the Bunsen, owing to its quick manipulation, has much to recommend it.

The Lummer-Brodhun screen consists usually of an opaque piece of gypsum and a set of right-angle prisms with their hypothenusal faces partially coinciding, and mirrors so arranged as to reflect the light from both sides of the screen, as indicated in Fig. 2, where S is the screen, M, M, the mirrors, and P, p, the prisms. One prism, p, transmits the light and the other, P, reflects it, giving a double field of light which is viewed through the telescope at E. The two beams of light are lettered a and b; if they are of unequal power, the two "fields" of light present a marked contrast, and only become the same when both sides of the screen are equally illuminated. The field is a round spot and that of b is a ring surrounding this spot. The contrast is so marked that a balance can be obtained with great nicety.

The Bunsen screen, represented diagrammatically by Fig. 3, is probably more familiar, consisting simply of a piece of opaque paper, S, with a grease spot on it. Two mirrors, M, M, are set at such an angle as to reflect this spot and allow the observer to judge of the relative intensities of the fields on opposite sides of it. When the spot appears of equal strength in both mirrors the screen is receiving the same illumination on each side and the candle-power is read directly from the scale.

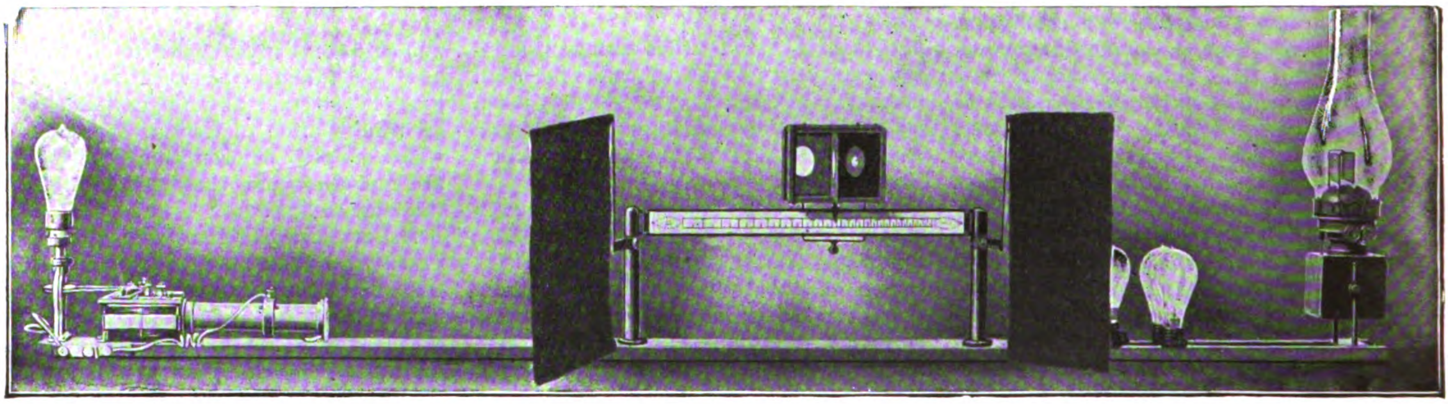

FIG. 4.—DESHLER-M'ALLISTER PORTABLE PHOTOMETER READY FOR USE.

The left hand pedestal carries the standard lamp in series with which is a regulating rheostat to enable it to burn at the exact voltage at which it gives 16 c.-p. The right hand pedestal carries the lamp to be tested, mounted in a revolving socket. A special arrangement allows the lamp to be put in or removed without stopping the socket. A controller permits the socket to be run at the desired speed of 180 revolutions per minute. An adjustable rheostat is also in series with the lamp to be tested, allowing the voltage across the lamp to be made anything desired within a small range. Between the pedestals is placed a table upon which rests two voltmeters and an ammeter. One voltmeter is connected across the terminals of the standard lamp and the other across the terminals of the lamp to be tested; the ammeter is placed in series with the tested lamp. One voltmeter may be dispensed with by putting in a throw-over switch, connecting the two lamps to one voltmeter and taking readings on each alternately.

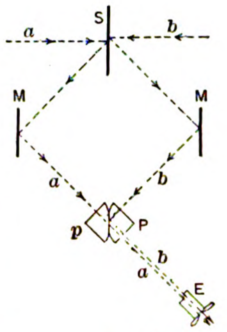

FIG. 2.

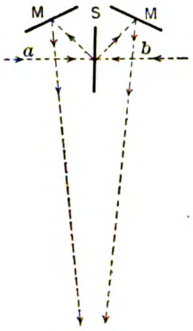

FIG. 3.

The Deshler-McAllister photometer, manufactured by the Electric Motor & Equipment Company, is made in the portable form, but when equipped with a rotating socket and mounted on a table or bench it becomes suitable for station work. (See Fig. 4.) The instrument is about 5 ft. long and can be folded up. The working standard of light is a duplex oil lamp at the right hand end of the instrument. This lamp is lighted and allowed to burn twenty minutes; then it is calibrated by a standard incandescent lamp. Calibration is effected by placing a standard lamp in the socket which the tested lamp occupies, placing the screen at the 16-c.-p. mark on the scale, and adjusting the oil flame until a balance of "fields" is effected. The screen is of the Bunsen type, riding over a celluloid scale on which the candle-power is marked. The station type of instrument is now fitted with a rotating lamp-socket at the left hand end and an ordinary lamp-socket at the right, the oil lamp being dispensed with.

Each lamp has in series with it a regulating rheostat for adjusting the voltage. The standard incandescent lamp has many advantages over the oil flame and its adoption has greatly improved the instrument. Two black cloth screens shield the observer's eye from the rays of the standard and tested lamps. A voltmeter and an ammeter are placed either on the bench or mounted on the back of the instrument in plain view. For rapid work the large illuminated dial type of instrument mounted directly back of the carriage has many advantages, being in plain view and easily read by the observer by simply raising his eyes.

In succeeding articles the details of photometric testing and its commercial advantages to central stations will be brought out.

INTERIOR TELEPHONE SYSTEMS.—I.

BY W. S. HENRY.

The object of these articles is to describe the various telephone systems that may be used for house, office or factory buildings. In order to make the list complete we shall start with comparatively insignificant arrangements and work up gradually to the small simple central switchboard system. There will be, therefore, a more or less complete collection of systems rather than anything original. The systems to be considered may be divided into series party lines, bridging party lines, intercommunicating systems, and small central switchboard systems. In these systems either magneto or microphone transmitters may be used, and the signalling apparatus may be either magneto bells and generators or the common vibrating bell and battery.

Where microphone transmitters or vibrating bells are employed the batteries may be distributed at the various stations or, in some cases, all concentrated at one place. It is generally desirable, although not really necessary, so to arrange the circuits that the bell at the calling station, or the home bell, as it is called, should ring when calling up another station. This assures the person signalling that his own circuit and probably the whole system is in working order, and that his call is being transmitted to the desired station.

Magneto instruments as transmitters are so very much less satisfactory than microphones that but little attention will be devoted to systems using such transmitters. They should be employed only where extreme simplicity or the absence of all batteries is absolutely necessary. Magneto transmitters have been used successfully as an experiment over a line of 600 miles in length, and they are superior, as far as clear articulation is concerned, to the microphone transmitter. The great and, so far, insurmountable objection to their use is the lack of volume, or loudness, due to the limited amount of energy that they can be made to translate. Ordinarily well-made and powerful double-pole receivers may be used as transmitters. Such instruments are usually wound to have from 75 to 100 ohms resistance, and therefore when such high resistance instruments are employed, mechanical considerations alone need be taken into account in selecting the size or quality of the line wire for interior systems where the line wires are comparatively short. The permanent magnets in good double-pole receivers, without any current through the coils, should be able to hold up a piece of iron weighing 4½ or 5 pounds.

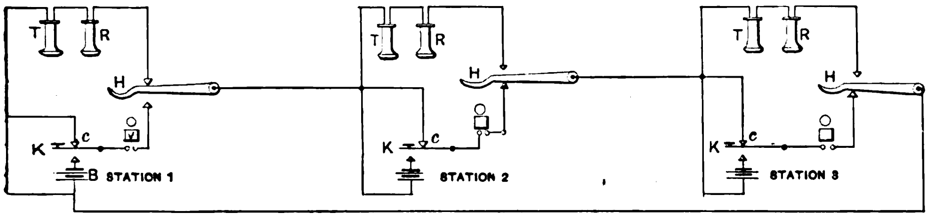

FIG. 1.—SERIES SYSTEM WITH MAGNETO TRANSMITTERS AND SIGNALLING BATTERIES.

With each microphone transmitter one or two good wet battery cells (Gordon, some reliable form of Leclanche with large surface zincs, or Fuller bichromate cells) are preferably used. Except in special cases, where the batteries are used often and long each time, the Leclanche cells are very satisfactory. On account of their low internal resistance and their ability to furnish a large, steady current without polarizing, the Gordon cells work well where Leclanche cells would not be suitable at all.

One of the simplest telephone systems comprises magneto instruments connected in series in one line. Calling apparatus of some kind is necessary, requiring some simple form of switch. There should preferably be two magneto instruments at each station, one to be used as a transmitter and the other as a receiver. Fig. 1 shows an arrangement requiring at each station two magneto instruments; T is the transmitter and R is the receiver. An ordinary vibrating battery bell, V, a battery, B, of two or more cells, and a hook switch, H, complete the equipment. When the receiver, R, is hanging on the hook, the line is connected to the lower contact; when the receiver is removed, a spring pulls the lever up against the contact, b. The smaller auxiliary switch, l, is arranged to normally rest on the contact, c. It may be pressed down upon d, but when released it should be returned to c by a good stiff spring.

Depressing the lever, K, at any one of the stations, puts the battery at that station in circuit with all of the bells at the other stations, provided the receiver hooks, H, are down; hence it is necessary that only one bell of those in circuit should be a vibrating bell, otherwise the vibrators will interfere with each other and impair the reliability of the signal. For this reason only one of the bells in the diagram is marked V; it does not matter which bell is the vibrator. If one of the receiver hooks is up, the current from the battery goes through the transmitter and receiver at that station instead of through the bell, as an inspection of the circuit at Station 1, in the diagram, will show.

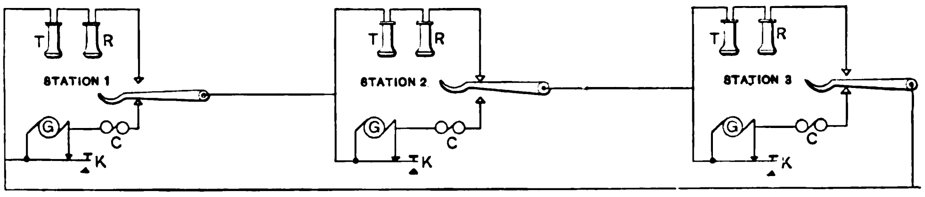

FIG. 2.—SERIES SYSTEM WITH MAGNETO TRANSMITTERS AND GENERATORS.

It is evident, therefore, that a station cannot be called up when its receiver is off the hook. Inasmuch as the talking current generated by any one of the magneto transmitters must pass through all of the signalling bells, except at stations where the receiver is off its hook, this arrangement is only suitable for a very small number of stations, the resistance and the inductive reaction of the bell magnet coils being so great when a number of stations are installed that the feeble current induced by the transmitter is so weakened as to render communication uncertain.

In Fig. 2 a very similar arrangement is shown, the only difference being the use of magneto generators, G, in the place of the signalling batteries, B, of Fig. 1, and the substitution of magneto bells for the simple bells used in the first system. The signalling key, K, is only the upper contact, so that a reverse-contact push button may be used instead of a lever arrangement, the push button being designed to normally short circuit the generator, G, as indicated in the sketch. Most magneto generators, however, are provided with an automatic arrangement on the spindle which short-circuits the armature of the magneto whenever the spindle is at rest. The act of turning the handle of the magnet removes the short-circuit and allows the induced current to pass out to the line. When this type of magneto is used, the push button, K, is, of course, unnecessary. In signalling with a magneto which has not the automatic short-circuiting arrangement on its spindle, the most convenient procedure is to turn the handle continuously and to press the key or push button, K, as many times as required; when the magneto has an automatic arrangement, however, the handle must be turned and stopped as many times as it is desired to ring the bell at the distant end.

The arrangements described are known as series party lines, meaning that all of the stations connected up are in series with each other. As intimated above, when this arrangement is used even for a small number of stations the bell magnets should have as low resistance and as few turns of wire on them as possible, in order to reduce the impedance of the circuit, and the generators should be wound with rather fine wire, because the current generated must pass through all of the bells in series.

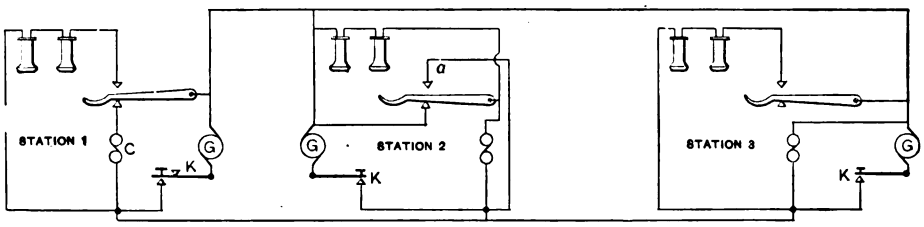

FIG. 3.—BRIDGING SYSTEM, WITH MAGNETO TRANSMITTERS AND GENERATORS.

In order to avoid forcing the talking current through the magnets of the signalling bells the latter may be "bridged" directly across the circuit, as shown in Fig. 3, in which case the bells may be wound for high resistance and impedance so that the talking currents will be turned past them. A high-impedance bell is made by using somewhat longer iron cores than in the ordinary series bell and by winding more turns of wire (about a No. 33 B. & S. gauge) upon it, making the resistance of the bell coils from 1000 to 1600 ohms. In Fig. 3 three different methods of bridging are shown. At Station 1 the bell is removed entirely from the circuit when the receiver hook is up; at

Station 2 the bell remains constantly across the circuit in series with the transmitter and receiver, but when the hook is up it is short-circuited by the hook and its upper contact through the wire, a; at Station 3 the bell remains permanently connected across the circuit, and when the receiver hook is up the transmitter and receiver are connected in parallel with it.

At first sight it might appear that the presence of the bell magnets as a permanent shunt around the talking apparatus at Station 3 would seriously interfere with the talking current. This would be the case were it not that the bell magnets, on account of their high self-induction and resistance, form an almost impassable barrier to the flow of the very rapidly-fluctuating talking current, and for this reason transmission of the talking current is not perceptibly affected. The impedance, or the total opposition due to resistance and induction, of a 1000-ohm bell-magnet to the ringing current, the frequency of which is about 15 periods a second, is about 1200 ohms; but to the talking current, the average frequency of which is at least as high as 300 periods a second, the impedance is from 4000 to 8000 ohms.

It is evident, then, that the bell magnets act only as very high resistance shunts from one line wire to the other, and allow only an inappreciable part of the talking current to leak through them, so that the talking currents pass through the two instruments in use about as well as if no bell magnets were connected across the two line wires. However, to the ringing current, on account of its lower frequency, the impedance is but little larger than the resistance of the coils, and consequently the ringing current readily flows through the bell coils.

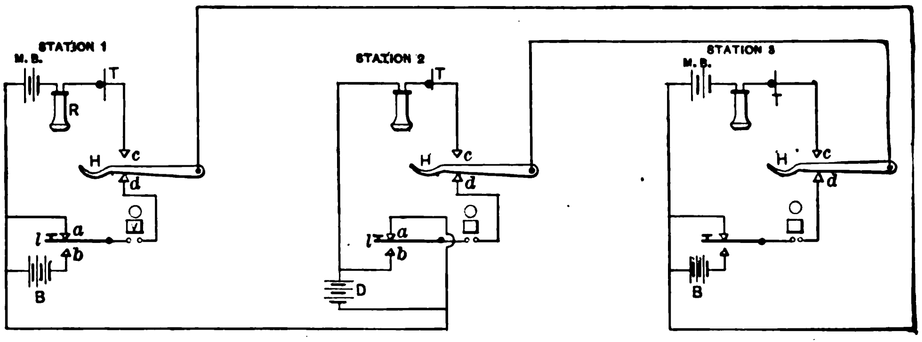

FIG. 4.—SERIES SYSTEM WITH MICROPHONES AND BATTERIES.

Since the bells are arranged in parallel across the line wires, the generators must supply enough current to ring all of them, and therefore the generators should furnish a large amount of current, rather than a high e.m.f. For this reason they are usually wound to a comparatively low resistance (250 to 350 ohms).

At all three stations of Fig. 3 the signalling key, K, is a single contact arrangement, and may be an ordinary push button. The generators are normally on open circuit and not connected across the two line wires. When a generator is to be used it is necessary to close the circuit by depressing the push button, K, or the generator may be made, as is usually done, with an automatic device on the spindle which will close the circuit only while the handle is being turned. The arrangement shown in this diagram gives much better results than the series-bell arrangement shown in the preceding figure, and a larger number of stations may be used if arranged in this manner than if the series plan shown in Fig. 2 be employed.

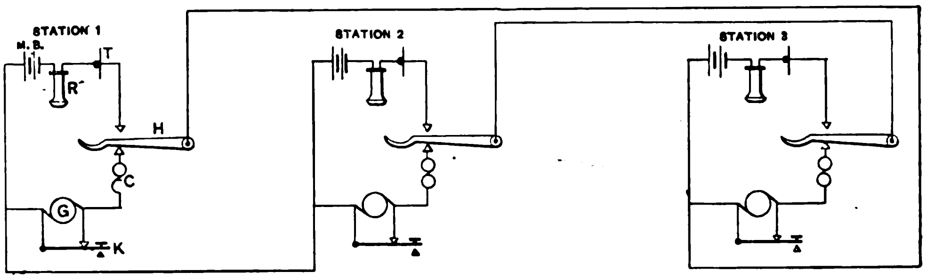

FIG. 5.—SERIES SYSTEM WITH MICROPHONES AND MAGNETOS.

Fig. 4 shows the simplest method of using microphone transmitters. The instruments are a transmitter, T; an ordinary receiver, R; a vibrating bell, V, and one or two separate batteries at each station. The battery, B, is used only for ringing the bells; the battery, M. B., only for operating the microphone transmitters, and the battery, D, for both purposes. In this arrangement, as well as in the one shown by Fig. 5, the microphones, receivers, and microphone batteries are directly in series with the line, no induction coils being used. In such systems the receivers should be low in resistance, about 10 or 20 ohms, and the microphone batteries, M. B., should be steady, closed-circuit cells of low internal resistance, such as the Gordon or Fuller bichromate. Enough cells will be needed at M. B. in each station to furnish about 100 milliamperes through the resistance of one transmitter, one receiver, and about one-half of the line wire. Such an arrangement of transmitters without induction coils is not very desirable.

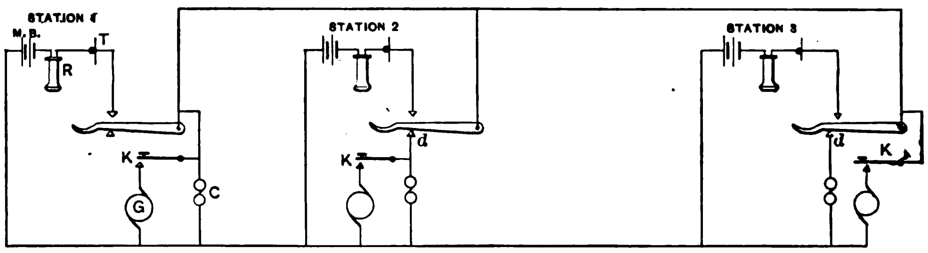

FIG. 6.—BRIDGING SYSTEM WITH MICROPHONES AND MAGNETOS.

The batteries marked B may be Leclanche or other open-circuit cells. The hand switch, l, should have a stiff spring which will normally keep it against the contact, a. To signal, the switch, K, is pressed against b one or more times, depending upon the number of the stations to be called. Depressing l at Station 1, or at Station 3, throws the battery, B, into the line circuit, and depressing l at Station 2 throws battery D into the line circuit; in either case all the bells ring. After calling, the receiver is removed from the hook and (K having returned to a) we now have the receiver, R, microphone, T, microphone battery, M. B., at Station 1, or Station 3, or the battery, D, at Station 2, directly in series with the line wires.

In such a system it is necessary that all the batteries should be symmetrically connected in the circuit, so that no matter what two stations are in use, their batteries, which will be in series, will not oppose one another. If the circuits are arranged as at Station 2, so that the same battery does for ringing and talking, enough cells must be used at D in each station to properly operate the microphone or to ring all the bells. As in Fig. 1, all the vibrators on the bells should be short-circuited, except one.

Instead of vibrating bells and batteries for ringing, we may use a polarized bell, C, and a generator, G, as shown in Fig. 5. The generator has an automatic device, or else a push button, K, which normally short-circuits it. In such an arrangement the talking current must pass through all the polarized bells except those at the stations where the receivers are removed from the hooks.

A better arrangement is to use high-impedance bells bridged across the two line wires, as shown in Fig. 6. The generator, as explained in connection with

Fig. 3, is normally on open circuit, a push or automatic circuit-closing device on the spindle being used to connect it across the line wires when the handle is turned.

Three bridging methods are shown. At Station 1 some of the current from the battery, M. B., can flow through the bell when the receiver is off the hook, but this will do no harm; in fact it may be beneficial, for it allows a larger direct steady current to flow through the microphone. The fluctuations in the current produced by the microphone can not pass through the bell-magnet coils but pass through the line circuit on account of the lower impedance of the latter. At Station 3 the bell is cut out when the hook switch is raised, and at Station 2 both the generator and bell circuits are cut off by raising the hook. An extra contact, d, is required at these two stations, but on the other hand, there are two bells less across the circuit to form shunts or leaks for the current when two parties are conversing. On the whole, the arrangement at Station 3 is the best of the three.

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THE ELECTROLYTIC PRODUCTION OF SODA AND CHLORINE.—III.

BY JAMES F. HOBART.

Returning again to the study of changes which take place during electrolysis, we are reminded that chemical affinity is the basis of all operations in this line; therefore we must study that matter in order to fully understand the work to be done in future. Chemical affinity is that force which induces atoms to unite and form chemical molecules. It is induced or influenced by various causes, among them being cohesion, solution, heat, light and electricity. The electro-chemical attraction of oxygen by zinc may be accounted for by supposing that all substances possess a definite amount of attraction for electricity, and that the attraction of zinc in this respect exceeds that of copper and the other metals. We may then regard the zinc as attracting its electric charge rather than as attracting the oxygen.

Another and later view of the matter is that chemical affinity may be caused by the opposite attractions of electrical charges naturally possessed by the atoms of matter. This would appear to be rendered probable by the law of electro-chemical equivalency (valency). Thus we may regard electricity as the vital spark of all chemical unions. Lodge says: "The electric charge belonging to each atom of matter is a simple multiple of a definite quantity of electricity, which quantity is an absolute constant, quite independent of the nature of the particular substance to which the atom belongs. The specific charge thus hypothetically given to each atom of matter is believed never to be lost. Atoms capable of entering into combination with each other are supposed to be oppositely charged. Hence chemical affinity is, as stated above, the result of mutual attractions of opposite electrical charges naturally and originally possessed by the atoms of matter."

Following out this theory, Lodge also points out that: (1) The amount of electricity possessed by each monad atom is exceedingly small, being about the hundred thousand millionth part of the ordinary electrostatic unit, or less than the hundred trillionth of a coulomb. (2) The charge being small, the potential is necessarily low; probably between one and three volts is a high difference of potential between two oppositely charged atoms (and to electrolize these atoms it is only necessary to provide a current of sufficient voltage to overcome this difference of potential, plus the ohmic resistance of the apparatus). (3) The nearness of the attracting atoms causes a very strong electrostatic attraction between them. (4) Chemical affinity or atomic attraction is caused by the presence of these electric charges. (5) The electrical force between two atoms at any distance is ten thousand million billion billion times greater than their gravitation attraction at the same distance, or the force has an intensity per unit of mass capable of producing an acceleration nearly one trillion times greater than that of gravity at the earth's surface.

ELECTRO-CHEMICAL EQUIVALENTS.

Elements.	Symbol.	Valency.	Atomic Weight.	Chemical Equivalent.	Electro-Chemical Equivalent (Grammes per Coulomb).	Coulombs per Gramme. q.	Grammes per Ampere-Hour. w.	Log. q.	Log. w.
Electro-Positive.									
Hydrogen	H	1	1.	1.	.000010384	96293.00	0.03738	4.9836353	2.5727090
Potassium	K	1	39.04	39.04	.00040539	2467.50	1.45950	3.3922572	0.1042041
Sodium	Na	1	22.99	22.99	.00023873	4188.90	0.185942	3.6221000	1.9342055
Calcium	Ca	2	20.5	10.25	.000106436	9395.31	0.383167	3.6730396	1.5847138
Manganese	Mn	2	53.9	27.	.000280368	3563.74	1.01151	3.5530838	0.004980
Magnesium	Mg	2	23.94	11.97	.00012430	804.03	4.47470	2.955411	0.6507614
Aluminum	Al	3	27.3	9.1	.00009449	1058.30	3.14180	3.0245939	0.5317086
Copper	Cu	2	63.0	31.5	.00032709	3058.60	1.17700	3.4855227	0.0707765
Gold	Au	3	169.2	65.4	.00067911	1473.50	2.44480	3.1683501	0.3882433
Iron	Fe	2	55.9	27.96	.00019356	5166.4	0.69681	3.7135894	1.843131
Lead	Pb	2	206.4	103.2	.00107160	933.26	3.185780	2.9700027	0.5863397
Mercury	Hg	2	199.8	99.9	.0013740	963.99	3.73150	2.9840725	0.5722325
Silver	Ag	1	107.66	107.66	.00111800	894.41	4.02500	2.9515366	0.6047659
Nickel	Ni	2	58.6	29.3	.00030425	3286.80	1.09530	3.5167733	0.0395331
Tin	Su	2	117.8	58.9	.00061152	1635.00	2.20180	3.2135178	0.3427779
Zinc	Zn	2	64.9	32.45	.00033696	2967.10	1.21330	3.4723322	0.0839682
Electro-Negative.									
Oxygen	O	2	15.96	7.98	.00008286	12068.5	0.2962958	3.0841910	1.4746648
Chlorine	Cl	1	35.37	35.37	.00036728	2722.71	1.322202	3.4359601	0.1213004
Carbon	C	2	11.97	5.98	.000062096	16104.	0.2235448	4.2069336	1.3493670
Bromine	Br	1	79..5	79.75	.00082812	1207.55	2.981237	3.0836870	0.4743984
Fluorine	F	1	19.06	19.06	.00019792	5052.54	0.7124116	3.7039274	1.8527950
Iodine	I	1	126.53	.26.53	.00131390	6710.99	4.7291053	3.8273210	0.6748659
Sulphur	S	2	31.98	15.94	.00016552	6041.56	0.5958731	3.8715122	1.7751534
Phosphorus	P	2	30.96	15.48	.0016074	6121.22	0.5786658	3.7869782	1.7624274
Nitrogen	N	3	14.01	4.67	.00004849	2062.28	0.1786304	3.3148770	1.251955

The elementary atoms being held together then by electrical attraction, it is not surprising that they may be separated by an opposing electrical force of greater strength than that which unites or holds them in combination. If we know the chemical and electro-chemical equivalents of the elements, therefore, we can, as stated previously, ascertain how much electrolytic work can be done by a given current of electricity. This data is supplied by the table given herewith.

In preparing this table it was based upon the fact, determined experimentally, that one coulomb of electricity expended electrolytically will liberate .000010384 gram of hydrogen; therefore a current of one ampere will liberate .000010384 gram of hydrogen per second. The number .000010384 is the electro-chemical equivalent of hydrogen. The electro-chemical equivalents of the other elements are obtained by multiplying the electro-chemical equivalent of hydrogen by the chemical equivalent of the substance. Multiplying the electro-chemical equivalent of any substance by the strength of current amperes which passes, gives the weight of that substance liberated by electrolysis.

The table gives only a part of the seventy elements, those not likely to be used in ordinary electro-chemistry not being included. The logarithms given serve to greatly facilitate the calculations necessary for computing electrolytic examples and problems. Referring to the table it will be seen that the elements are divided into two groups, electro-positive and electro-negative; there are no neutrals.

When an electric current is sent through an electrolyte the decomposition which ensues is called electrolytic decomposition. There are different views as to what actually happens in such a case. Some writers claim that when, through electrolysis, an electro-motive force is brought to bear on a molecule of matter, say muratic acid, HCl, the liberated hydrogen atoms travel, on the whole, in one direction, and the liberated chlorine atoms travel in the opposite direction. The atoms thus moving through the liquid may, by their electric charges, be said to convey electricity, and this fact has given rise to the term "electrolytic conduction." In electrolytic conduction, the changes are necessarily equal, but the speeds of their motion are unequal. In a given liquid, each atom has its own rate of motion, no matter with what it has been combined. Hydrogen travels faster than any other kind of atom, and the conductivity of the liquid depends upon the sum of the speeds with which the two opposed atoms travel. This is known as the "double-fluid" hypothesis. It is rejected by many scientists, and Grothüss claims that the molecules flow first in one direction and then in the other as they travel back and forth between the anode and cathode, giving up their charges of current and matter, and accordingly as they carry more or less of either of the elements.

Some electrolytes, such as various mixtures of sulphuric acid and water, do seem to possess a true power of conducting electricity, and therefore have a specific resistance, and are heated by the passage of current, like an ordinary conductor. Generally, however, the passage of the electrolyzing current is regarded as different from that of a current which merely heats a conductor, that latter being distinguished from electrolytes in that the latter do not allow electricity to pass save by undergoing chemical decomposition themselves.

The resistances offered by various salts in solution have an important bearing upon the economy electrolysis. Many persons have the idea that water is a very good conductor, but, on the contrary, water in a pure state is an almost perfect non-conductor. (An absolute non-conductor does not exist, as all substances are conductors of electricity to some extent, the good conductors being called "conductors," the poor ones "insulators.") In computing specific resistances of liquids they are compared with a cubic centimeter of pure silver, which has a resistance at 0 degree C. of 1504 microhms (.000,001,-504 ohm). The resistance of a cubic centimeter of pure water at 75 degrees C. (167 degrees F.) is 118,800,000 ohms; therefore, pure water has a specific resistance of 78,916,888,224,734.

I give herewith the resistances per cubic centimeter of a few liquids likely to be used in electro-chemistry; they are as determined by Lupton:

Pure water, at 75 degrees C., 118,800,000 ohms.

Pure water, at 4 degrees C., 9,100,000 ohms.

Pure water, at 11 degrees C., 340,000 ohms.

Dilute sulphuric acid (5 per cent. acid), at 18 degrees C., 4.88 ohms.

Dilute sulphuric acid (3 per cent. acid), at 18 degrees C., 1.38 ohms.

Nitric acid (density 1.32), at 18 degrees C., 1.61 ohms.

Saturated solution of copper sulphate (blue vitriol), at 10 degrees C., 29.30 ohms.

Saturated solution of zinc sulphate, at 14 degrees C., 21.5 ohms.

Hydrochloric (muriatic) acid (20 per cent. acid), at 18 degrees C., 1.34 ohms.

Muriate of ammonium (sal-ammoniac), 25 per cent. salt, 2.53 ohms.

Sodium chloride (common salt), saturated at 13 degrees C., 5.3 ohms.

It will be observed that the resistance varies considerably with the temperature, a fact which should be taken advantage of in electrolysis.

Having determined the resistance of one cubic centimeter of electrolyte, it is easy to calculate the total resistance of any body of that liquid by multiplying the distance in centimeters from the anode to the cathode by the resistance per cubic centimeter, and dividing by the transverse cross-sectional area of the liquid in square centimeters. For example, one cubic centimeter of salt solution has a resistance of 5.3 ohms; if a vessel contains 100 cubic centimeters, and is of such a shape that the area from anode to cathode is 50 centimeters long, two centimeters wide and two centimeters deep, the resistance of the path of the current through the electrolyte will be

$$\frac{25 \times 5.3}{4} = 33.1 \text{ ohms.}$$

If, on the other hand, the vessel is arranged so that the area from the anode to the cathode is 10 centimeters long, and the vertical cross-section measures five centimeters in width and two centimeters in depth, then the resistance will be only

$$\frac{10 \times 5.3}{10} = 5.3 \text{ ohms.}$$

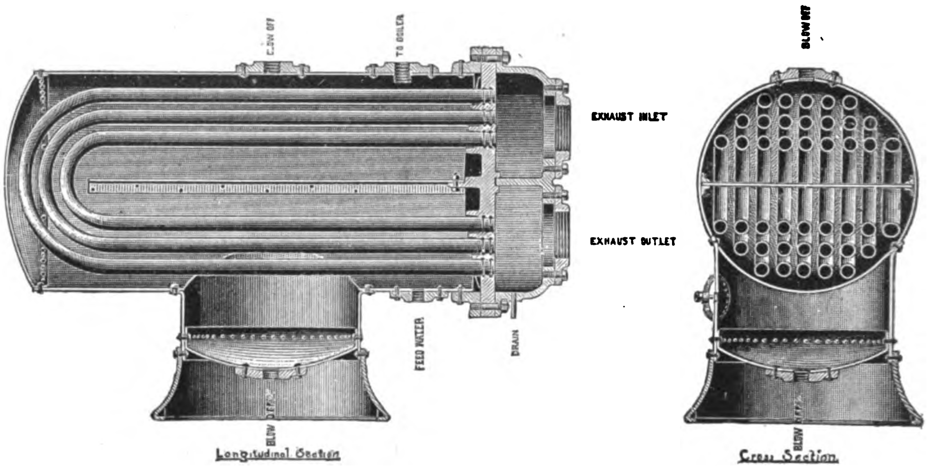

FIG. 1—STILWELL HEATER: LONGITUDINAL AND CROSS SECTIONS.

It will be obvious from the foregoing that the larger the area of the anode and cathode surfaces and the vertical cross-section of the body of liquid, the lower will be the resistance, and the nearer the electrodes can be brought to each other the lower also will be the resistance.

Besides the specific conduction resistance of the electrolyte, there is also to be considered the electrolytic resistance, or the potential produced in opposition to the decomposing current from the dynamo. Such potential is produced by the anode, cathode and electrolyte acting as an independent primary battery, and the e.m.f. of the dynamo must be high enough to overcome this counter e.m.f., or "back pressure," as well as the conductive resistance of the electrolyte. Various metals have certain fixed electromotive forces when combined with certain liquids. This is constant, no matter how large may be the surfaces exposed; thus, the "back pressure" in an electrolytic cell ten feet square is no greater than in one half a centimeter square.

The laws of electrolysis and the methods of determining the opposing electromotive force of various elements will be discussed in the next paper, after which several cells will be illustrated and described, and drawings given showing an electrolytic plant in operation.

FEED-WATER HEATERS.—I.

Several of the well-known feed-water heaters have already been noted in the articles on steam appliances, notably in the January and February issues, where oil and grease extractors were described. Among the heaters thus mentioned, which also may be regarded as extractors, are the Excelsior combined feed-water heater, purifier, filter and oil separator, made by the Harrisburg (Pa.) Pipe Bending Company; the Pittsburg feed-water heater and purifier made by the Pittsburg Feed-Water Heater Company, Pittsburg; the Cookson feed-water heater made by the Bates Machine Company, Joliet, Ill., and the Hoppes separator, built by the Hoppes Separator Company, Springfield, Ohio.

The majority of the feed-water heaters commonly in use may be divided into two classes, one class being made in the form of one or more coils enclosed in a case or shell, and the other using straight tubes. There is also a small class of combination coil and parallel tubes, and another still smaller collection of heaters having baffle plates and other appliances separate from the usual tube construction.

Fig. 1 shows the Stilwell close heater, as made by the Stilwell-Bierce & Smith-Vaile Company, Dayton, Ohio. This is a combination coil and tubular heater, or really is a return tubular concern, the exhaust entering and leaving at the same end of the shell, and passing through the tubes instead of around them, as in the device above described. The tubes are U-shaped and are made of seamless brass, and so fastened to the heads that they never become loose or leaky. The heater stands on a base which serves as a mud well or settling chamber, from which the deposited impurities can be readily blown off. There is a diaphragm which separates the shell and compels the feed water to traverse the entire length of the shell and heating tubes. The exit of the water is at a point close to where the hottest steam is found, thus ensuring the hottest possible temperature of the feed water. By the construction of the settling chamber, a deposit therein does not reduce the heating power of the heater in the least. The tubes and tube sheet can be readily removed from the shell for cleaning, when necessary. This concern also makes a lime-extracting heater and filter combined, in which the lime is deposited upon pans or partitions, from whence it can be readily removed through a door in the shell.

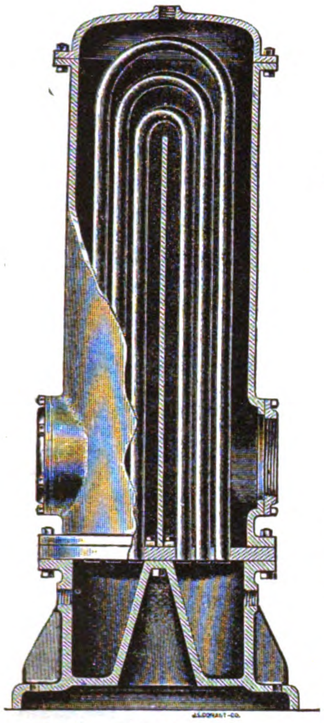

FIG. 2.—HARDWICK.

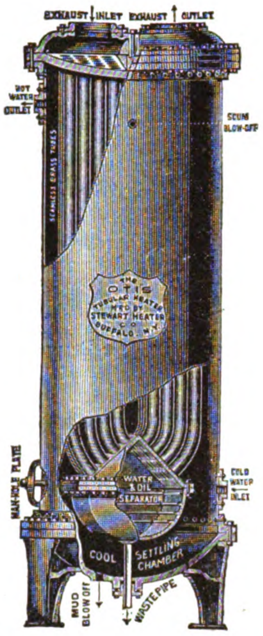
EXHAUST INLET
EXHAUST OUTLET
HOT WATER OUTLET
SCUM BLOW-OFF
SEAMLESS BRASS TUBES
THE OTIS TUBULAR HEATER MFD BY STEWART HEATER CO. BUFFALO, N.Y.
MAN-HOLE PLATE
WATER & OIL SEPARATOR
COLD WATER INLET
COOL SETTLING CHAMBER
MUD BLOW OFF
WASTE PIPE

FIG. 3.—OTIS HEATER.

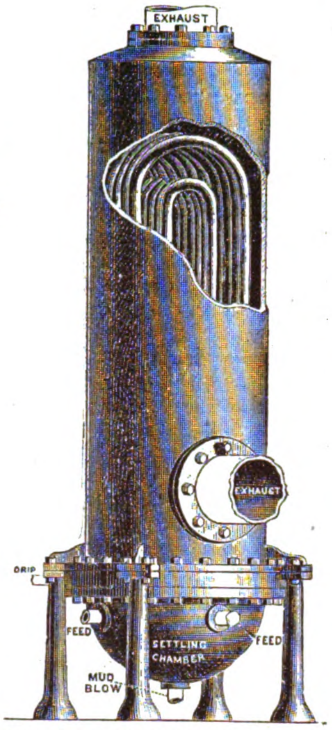
EXHAUST
EXHAUST
DRIP
FEED
SETTLING CHAMBER
FEED
MUD BLOW

FIG. 4.—DEVRIES BERRYMAN.

The Hardwick heater, made by the Erie Manufacturing & Supply Company, Erie, Pa., is of somewhat similar construction, as an inspection of Fig. 2 will show. In this heater the steam passes around the tubes, the feed water through them. The tubes are so arranged that they enter separate portions of the head, which is attached to receiving and discharge chambers, which are separated so that there is no effect between the hot and the cold water as it enters or leaves the heater. This heater also has the diaphragm and U-shaped tubes already described.

The Otis heater, Fig. 3, by the Stewart Heater Company, Buffalo, N. Y., is also of the U-tube variety, and is made with an oil and water-separating device in the bottom of the shell, at the bend of the tubes. Here the exhaust steam goes through the tubes, and the water goes through the shell, entering and leaving horizontally just above the bottom. The lower portion of the shell serves as a cool settling chamber and catches a good deal of matter which would not be stopped were that portion of the heater kept hot. This company also makes the Stewart heater, which has been described in the oil-separator articles. These, as are most other makes of heaters, are made in both vertical and horizontal types.

Another type of the U-tube heater is made by Benjamin E. Kelley & Son, 91 Liberty Street, New York. This heater, shown by Fig. 5, consists of a cast-iron shell containing U-tubes in which the water is carried. Steam enters at the side, close to the bottom, and leaves vertically at the top of the case. These heaters are also made in horizontal form when required, and a special heater is also made for condensing engines. Usually the feed water is delivered to the boiler at a temperature of 150 to 160 deg., but it must be remembered that the higher the vacuum, the lower will be the feed-water temperature. The form of heater referred to is known as the Kelley Berryman.

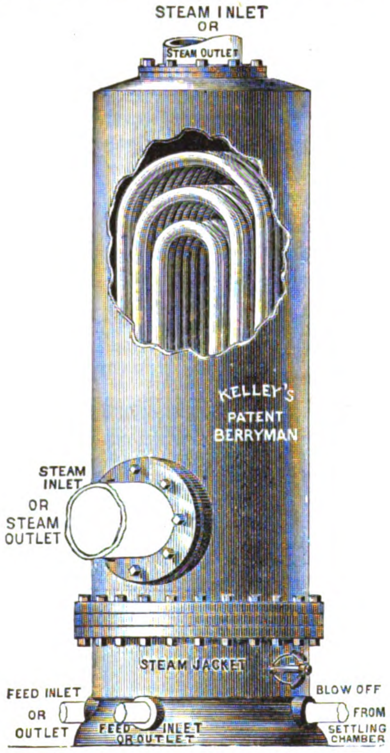
STEAM INLET OR STEAM OUTLET
KELLEY'S PATENT BERRYMAN
STEAM INLET OR STEAM OUTLET
STEAM JACKET
FEED INLET OR OUTLET
FEED INLET OR OUTLET
BLOW OFF FROM SETTLING CHAMBER

FIG. 5.—KELLEY BERRYMAN HEATER.

There is also in the field another and similar heater, known as the Devries water-tube Berryman. This type is shown by Fig. 4. There is a peculiar bottom to this heater, by means of which the water is divided into small streams and flows through an entire bank of tubes at once, reducing the loss of power by friction. It will be noted that in both of these types of Berryman heater the water passes through the tubes instead of around them, as in the older forms of this heater.

Fig. 6 represents a return copper-coil heater, known both as the New World and as the Robertson, and built by Jas. L. Robertson & Sons, New York. In this heater the feed and outlet are both located on opposite sides of the lower part of the shell, thus giving straightway water connection. As the coils are confined only at these points, there is perfect freedom of expansion and contraction. The feed water, on entering, is carried to the top and then back to the bottom again, thus obtaining the benefit of the hottest steam both on entering and on leaving the heater. These heaters are, under ordinary circumstances, guaranteed to heat the feed water to within two degrees of the temperature of the exhaust steam.

The National feed-water heater is another of the coil type, and uses both the ordinary spiral and the parallel straight-side coil. It is made by the National Pipe Bending Company, New Haven, Conn. This heater can be economically used between the engine and the condenser; there is a notion among the steam users that

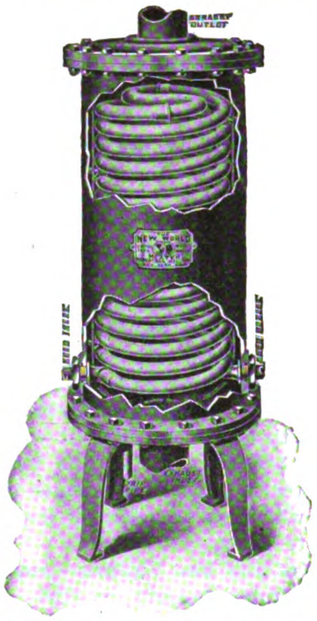
EXHAUST OUTLET
NEW WORLD
FEED INLET

FIG. 6.—ROBERTSON NEW WORLD HEATER.

this location is not advantageous, but where the area for the passage of exhaust steam is ample, as in this heater, there is no trouble in using it in the location mentioned. It is claimed that with this heater a temperature of 130 degrees in the feed water may be obtained readily with a vacuum of 26 inches of mercury, representing a saving of at least six per cent. of fuel over feeding cold water. If an auxiliary heater be used, the feed water can be raised to 200 degrees.

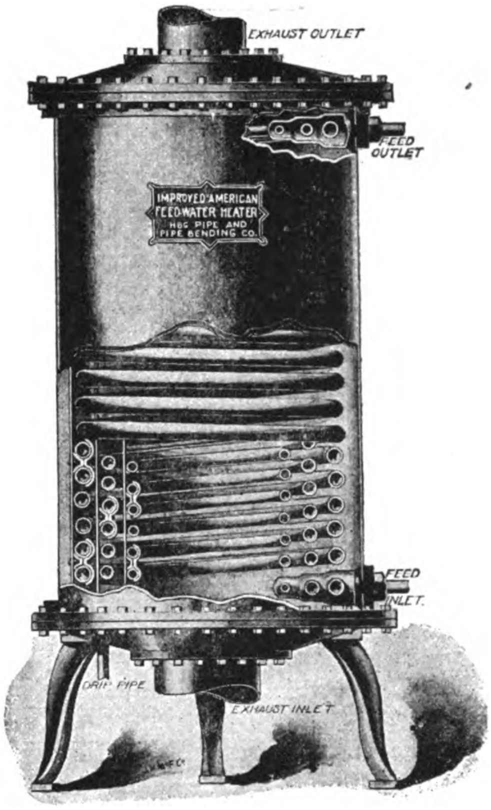
EXHAUST OUTLET
FEED OUTLET
IMPROVED AMERICAN FEED-WATER HEATER HBG PIPE AND PIPE BENDING CO.
FEED INLET
DRIP PIPE
EXHAUST INLET

FIG. 7.—AMERICAN HEATER.

Another heater of the coil variety, the American (Improved), is shown by Fig. 7, and is made by the Harrisburg (Pa.) Pipe Bending Company. This is a copper-coil heater, and is claimed to heat water up to from 206 to 212 degrees without back pressure on the engine. Here the water is in contact with the copper tubing only, the steam and not the water coming in contact with the shell. As seen by the engraving, there are three coils of different diameters, wound one within the other, and all starting from and ending in the same branch. The course of the exhaust is from bottom to top of the shell, and the feed water passes in the same direction through the coils. It will be also noted that the coils in this heater are supported in a peculiar manner by clamp stays, which are slipped over the coils and fitted to them.

One of the best known among the straight-tube heaters is the Goubert, shown by Fig. 8, in which the water passes through the tubes and the steam around them. The heater is so constructed that two cast-iron water chambers connected by brass tubes are the only parts under pressure. The cast-iron shell surrounding the tubes merely serves as an envelope for the exhaust steam. There is a flexible joint connecting the upper water chamber with the shell, so that expansion is taken care of, still allowing the lower water chamber to be bolted to the shell of the heater. The vertical type of the Goubert heater is recommended in every instance when there is room for it in the building. But the horizontal heater possesses nearly all the good points of the vertical appliance.

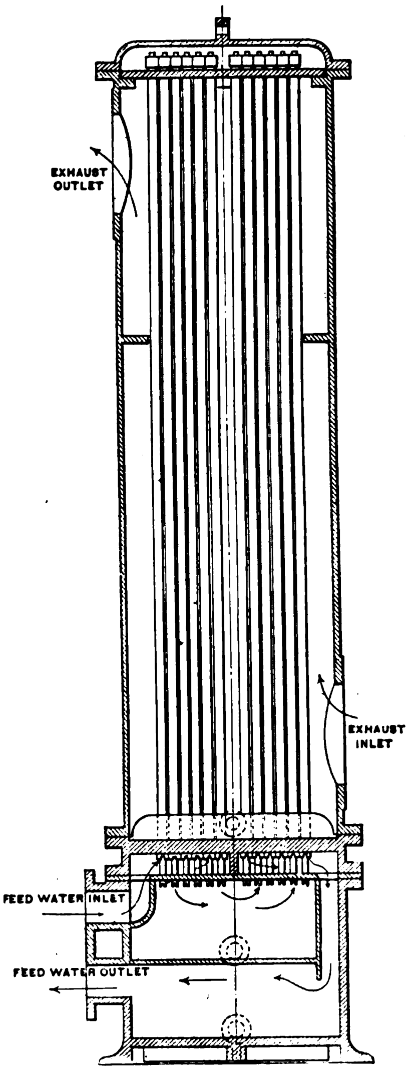

FIG. 9.—WHEELER HEATER.

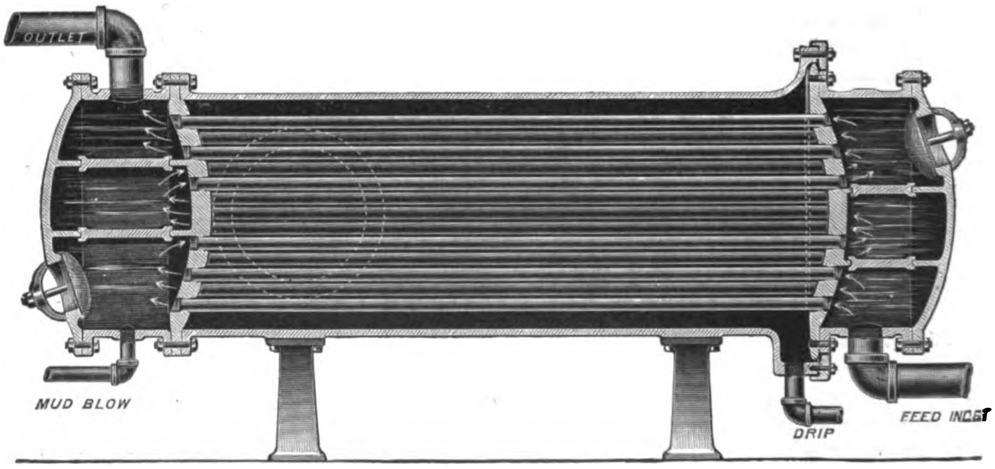

FIG. 8.—GOUBERT FEED WATER HEATER; HORIZONTAL TYPE.

The Wheeler heater, built by the Wheeler Condenser and Engineering Company, New York, is represented by Fig. 9. The feed-water pipes are close together and parallel at the bottom of the shell. The steam has a diagonal course upward, among and around the outside of the tubes, the water being within. In this heater there are small tubes inside of larger ones, each set fitted to a separate head. The water passes up the larger tubes and down through the smaller ones of the left-hand bank of tubes, after which it passes up through the smaller set of tubes in the right-hand section, and down through the larger tubes of this bank. The movement of the water is very peculiar, and the heater is so constructed that the water is exposed to the hottest steam as it leaves the heater.

◆

Lessons in Practical Electricity

TRANSFORMERS.

For simplicity, the effects of hysteresis and magnetic leakage will be ignored until after the relations between the primary and secondary windings have been explained. In this explanation it will be assumed that there is no transformation of e.m.f., so that the lines representing the primary and secondary voltages and currents may be drawn to the same scale. In order to distinguish between primary and secondary effects capital letters will be used to represent the former and small letters for the latter.

In Fig. 8 only the primary e.m.f. components were given. The only other force present, with the secondary open, is the primary current, which (ignoring hysteresis, etc.) is in phase with the ohmic e.m.f. component, or "drop." For better distinction this ohmic component or active e.m.f. will be hereafter represented by V and v, as applying to primary and secondary, respectively. Fig. 9 is a duplication of Fig. 8, with the addition of the primary-current vector, C. (Where one line represents several vectors it must be remembered that all of them originate at 0, the length of each being indicated by the distance from 0 to the proper arrow head.)

When the secondary circuit is closed, the current flowing in that winding at any instant is in the opposite direction to that in the primary winding, tending to neutralize the magnetizing effect of the primary current; the actual magnetizing force is the resultant of the two. If there is no inductance in the secondary circuit, the secondary current and e.m.f. will be in phase; the current, therefore, may be represented by a part of the same vector that represents the secondary e.m.f. This e.m.f. is in phase with the primary back e.m.f., E_1, because both are induced simultaneously by the magnetic flux in the core. Hence e_1 in Fig. 10 is identical with E_1 in Fig. 9. That part of the vector, e_1, from 0 to c, represents the secondary current, and the part from 0 to v represents the ohmic drop in the winding.

As above noted, the exciting force that creates the magnetic flux is the resultant of the primary and secondary ampere-turns. That is, the magnetizing force or effect is divided into two components, one of which is the primary ampere-turns and the other the secondary ampere-turns.

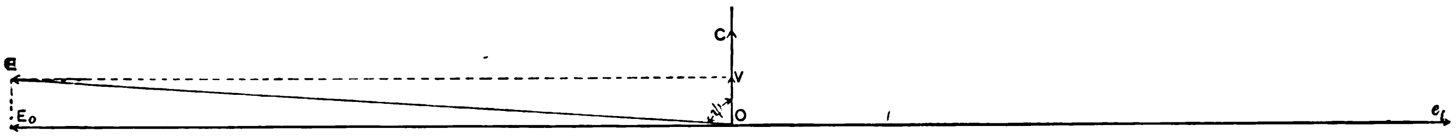

FIG. 9.—PHASE RELATIONS WITH THE SECONDARY CIRCUIT OPEN, IGNORING HYSTERESIS AND EDDY CURRENTS.

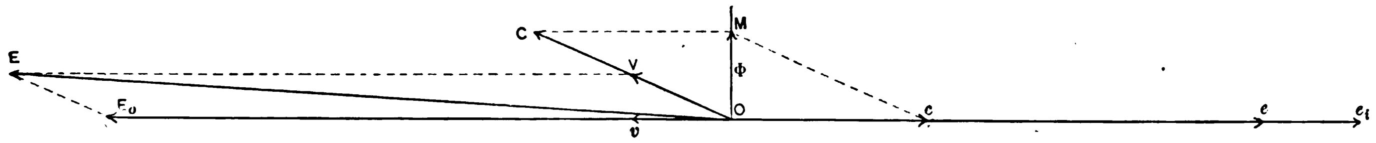

FIG. 10.—PHASE RELATIONS WITH THE SECONDARY CLOSED, IGNORING HYSTERESIS AND EDDY CURRENTS.

Knowing the value of the secondary current and the required magnetizing force, therefore, the value and phase of the primary current may be found by means of the parallelogram method. Fig. 10 illustrates this; the secondary current, c, combines with the primary current, C, to produce M, which corresponds with C in Fig. 9, where the primary current was the sole magnetizing force.

The primary ohmic e.m.f. remains in phase with the primary current, of course, being the component that forces the current through the winding. This is represented, therefore, by that part of the vector, C, Fig. 10, extending from 0 to V; combining this with the component, E_o, gives the value and phase of the impressed e.m.f., E, just as in Fig. 9. In both diagrams, the angle, Ψ, between the impressed e.m.f. vector and that of the primary current, is the "angle of lag," or the phase difference between the impressed e.m.f. and current, in 360ths of a cycle or period.

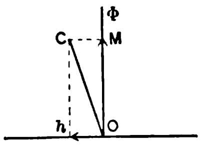

FIG. 11.—SHOWING THE DIFFERENCE OF PHASE BETWEEN THE MAGNETIC FLUX AND THE EXCITING CURRENT DUE TO HYSTERESIS AND EDDY CURRENTS.

As the diagrams show, this angle is very much wider when there is no load in the secondary than when that circuit is loaded, and the difference is much greater in practice than the diagrams indicate, because the proportionate lengths of M, C, c, V and v, with respect to E, E_o and E_1, are exaggerated here in order to make the diagram "open." A true diagram would show V about 1/100 the length of E; C would diminish accordingly, and the angles would be so small that they could not be clearly plotted in a diagram under two or three feet in length.

Up to this point it has been assumed that there were no eddy currents, hysteresis loss or magnetic leakage. As a matter of fact, all three are important factors in transformer operation and efficiency. The loss by hysteresis is due to the magnetic inertia of the core iron, which cannot be made to respond instantaneously to the exciting current. Eddy currents are currents which are induced in the core itself, flowing around the plates parallel with the wires of the coils. Both of these require energy to maintain them, and the primary current, therefore, may be considered as divided into two components, one magnetizing the core and the other supplying the hysteresis and eddy-current energy. The magnetizing component is in phase with the flux and the core-loss component 90 degrees ahead of it.

The exciting current, therefore, is not in phase with the magnetism, but leads it a little, as shown in Fig. 11, where M is the phase of the magnetizing component coincident with that of the flux, Φ; h is the core-loss component, and C is the resultant exciting current. Applying this correction to Fig. 9, the result is Fig. 12; and applying the same correction to Fig. 10 produces Fig. 13. Comparison of Figs. 9 and 12, therefore, discloses the effect of core losses upon the primary alone, and a similar comparison of Figs. 10 and 13 shows the effect upon primary and secondary together. All four diagrams are drawn to one scale; it will be noticed that the impressed e.m.f. vector is the same length in all.

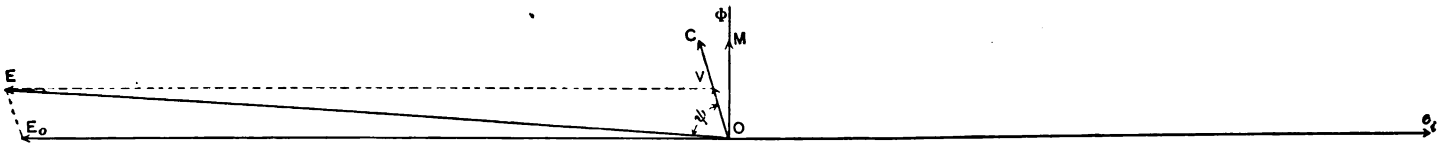

FIG. 12.—PHASE RELATIONS WITH THE SECONDARY CIRCUIT OPEN; TAKING INTO ACCOUNT HYSTERESIS AND EDDY CURRENTS.

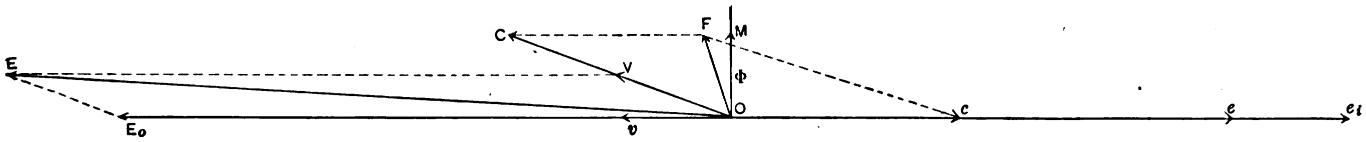

FIG. 13.—PHASE RELATIONS WITH THE SECONDARY CIRCUIT CLOSED, TAKING INTO ACCOUNT HYSTERESIS AND EDDY CURRENTS.

Letters on Practical Subjects

Wanted, Advice.

To the Editors of American Electrician:

Sirs:—I am in charge of a two-phase alternating-current plant consisting of 180-kw. generator driven by a turbine which is only taking about one-fifth of the capacity of the river. The two-phase current is transmitted at 2400 volts to the town three miles away and used there to supply lights and a few alternating-current fan motors. There is an increasing demand arising for power and a project is on foot to erect a cotton mill with about 5000 spindles and 300 looms to be driven electrically. I would be glad to have some of your readers express opinions as to the best method of increasing the output of the plant with a view to supplying the prospective demands indicated. Would it be advisable to add more alternators of the type now in use and distribute power in town by means of induction motors, or would it be preferable to use a rotary transformer at the town end and distribute that portion of the power for motor purposes by direct current, using the alternating current only for lights? It seems to me to be preferable to use direct-current motors for power purposes on account of the lagging current involved where induction motors are used. I hope that some of your other readers will favor me with suggestions on this subject through your columns.

Gus Smith.

Cuero, Tex., April 6, 1900.

Sulphur Dioxide Engines.

To the Editors of American Electrician:

Sirs:—In your editorial in the April number, on the use of sulphur dioxide to increase the heat range of a steam engine, you say that "if the condenser range is only 7 deg. this condition should be applied to the steam engine in order to obtain a reasonable comparison." I would like to call attention to the fact that the difficulty of working with a very small range in a steam condenser is that the volume of steam to be handled would be enormous and the cylinder condensation in the engine would be excessive. Supposing the condensing water temperature was 60 deg. F. and the temperature range in the condenser 10 deg., the steam would have to enter the condenser at 70 deg., which means an absolute pressure of .36 lb. per square inch.

Now, it is well known that a vacuum that will give this back pressure never is got in practice, but even if it was, the number of expansions would be unusually great; say the steam came to the cylinder at 105 lbs. absolute, it would have to expand nearly 292 times from the point of cut-off to the condenser. In other words, the cubical capacity of the condenser would have to be 292 times as great as the volume behind the high-pressure piston at the cut-off point. Of course this is not practical, to say nothing of the amount of condensation which would be caused by the greater number of expansions necessary.

Using the sulphur dioxide auxiliary engine, the steam engine could start with an initial pressure of, say, 185 lbs. absolute and expand down to, say, 12 lbs. terminal pressure; then the sulphur dioxide engine could take the heat units out of the steam at this point and work down to the limits imposed by the temperature of the condensing water. This would allow the steam engine to be smaller for a given output, and there would be the gain of whatever power the dioxide engine would develop.

Samuel C. Webber.

Chicago, Ill., April 10, 1900.

To the Editors of American Electrician:

Sirs:—I was very much interested in your editorial last month on steam engine efficiency, but I cannot see why an auxiliary engine worked by sulphur dioxide would not be an advantage. The ordinary temperature range of a compound-condensing engine is from about 366 down to 141 deg. F., a difference of 225 deg. Now the sulphur dioxide engine can extend this down to atmospheric temperature, say 76 deg. average. This is an increase of 141 — 76, or 65 deg., and the gain certainly amounts to about 65 ÷ 225, or about 29 per cent. of the heat range of the steam engine alone.

Jesse H. Cromwell.

New Orleans, La., April 12, 1900.

Electrolytic Production of Soda and Chlorine.

To the Editors of American Electrician:

Sirs:—In the articles on the above subject by Mr. James F. Hobart, which appeared in the March and April numbers of the American Electrician, a number of erroneous statements occur. These are of a fundamental character and, if unchallenged, might seriously mislead those whom the articles were intended to instruct. I take the liberty, therefore, of calling attention to them.

The statement on page 144, "Equal parts of the two combine to form the compound NaCl," and the alleged proof immediately following (which does not appear to be a proof of anything) tend to convey the idea that equal parts by weight of sodium and chlorine combine to form sodium chloride, which is untrue.

The statement on page 145 that "the atomic weight of sodium (Na) is 39.1, therefore the weight of a molecule of sodium chloride (NaCl), one atom each of the two elements, is 35.4 + 39.1 = 74.5" is far from accurate.

On page 189 Mr. Hobart gives correctly the chemical equivalent of sodium as 22.99 and in the next paragraph he again uses the value 39.1 in calculating the composition of sodium chloride. Further on, in stating the composition by weight of NaOH, he gives only half of the correct quantity of oxygen.

Other statements that are contrary to chemical and physical laws are those on page 144 about a "molecule of air"; for example, "Thus the smallest conceivable particle of air would be a molecule, which in turn could be divided into three parts, two of nitrogen and one of oxygen."

The voltage, "1.5 or 2 volts," which is given on page 189, would not be sufficient to supply the chemical energy needed to liberate chlorine, if the efficiency were 100 per cent.

Some of these statements may probably be attributable to the printer, such as the statement that "it will require 96.302 coulombs to liberate 'one grain'" of hydrogen, which should obviously read "one gram."

C. J. Reed.

Philadelphia, April 10, 1900.

To the Editors of American Electrician:

Sirs:—I beg leave to draw your attention to an error appearing in the articles in your March and April numbers which deal with the subject of "The Electrolytic Production of Soda and Chlorine." The error consists in the use of the quantity 30.1 as the atomic weight of sodium instead of 22.99, the correct equivalent. In Paper I. a part of the paragraph, third from the end, reads: "By the same rule the atomic weight of sodium (Na) is 39.1." The calculation following should be:

"35.4 + 22.99 = 58.39 (not 74.5);

and the one further on should read: "1000 parts would contain 1000 × 35.4 ÷ 59.39 = 606.26 parts of Cl; and 1000 × 22.99 ÷ 58.39 = 393.74 parts of Na."

In Paper II. (April issue), Mr. Hobart, after stating the atomic weight of sodium correctly in paragraph 3, uses in the succeeding paragraph the incorrect number quoted above (the atomic weight, by the way, of potassium, a kindred element). The calculations in this paragraph (4) should read: "Chloride of sodium contains 22.99/58.39 parts of sodium, and 22.99 × 453.6 ÷ 58.39 = 178.59 grams of sodium, requiring 178.59 × 4188.8 = 748,106 coulombs; a current for one hour of 207.8 amperes."

The weight of chlorine evolved is 453.6 — 178.59 = 275.01 grams, occupying 86 litres or about 3 cu. ft.

This error repeats itself, and to a large extent detracts from the otherwise useful paper.

A difficulty in connection with the practical application of the principles described exists in the possibility of the electrolytic action being annulled as these equations show in the reaction of the liberated chlorine gas upon the salt solution:

$$2\ NaOH + Cl_2 = 2NaOCl + H_2$$

$$3\ NaOCl = NaClO_3 + 2\ NaCl$$

$$NaClO_3 + 6\ H = NaCl + 3\ H_2O.$$

We have thus regained the salt we have attempted to decompose.

I hope to see in the series some interesting descriptions of the various electrolytic processes now used for the alkali production.

Student.

Toronto, Ont., April 9, 1900.

Electrical Catechism

454. What is the "Gilbert"?

The gilbert is the practical unit of magneto-motive force, and equals $\frac{1}{4\pi}$ ampere turn. The unit is named after William Gilbert (1540 to 1603), a court physician in England, who made a careful study of magnetism and wrote the first extended treatise on the subject.

455. What is an ampere-turn?

The magnetizing force of a current flowing through a coil equals the product of the current by the number of turns in the coil. A current of one ampere through a coil of 100 turns would have the same magnetic effect as a current of 10 amperes through a coil of 10 turns, provided both coils were of similar dimensions, having the same diameter and length. (If any iron is near, it must be assumed the same in the two cases.) In each case the magnetizing force is 4 π times 100 ampere turns, or 1256.6 gilberts.

456. What is reluctance?

Reluctance in a magnetic circuit corresponds closely with resistance in an electric circuit. The law for magnetic circuits is very similar to that for electric circuits. The magnetic flux (corresponding to current) equals the magneto-motive force (corresponding to voltage or electro-motive force) divided by reluctance.

457. What is the "Oersted"?

The oersted is the practical unit of reluctance, being such as to permit one gauss to traverse it under the action of a magneto-motive force of one gilbert. The unit is named after Hans Christian Oersted (1777 to 1851), a Danish physicist who discovered many of the laws of electro-magnetism.

458. How many kinds of current are there?

Currents may be classified on the basis of directionality into unidirectional, or direct, and alternating. The latter may be divided into harmonic and irregular. Unidirectional currents may be divided into constant (or continuous) pulsating and irregular curents. Sometimes currents are classified into galvanic (or voltaic) and induced (or faradic) currents.

459. What are voltaic or galvanic currents?

This is a name used by physicians for unidirectional steady currents such as given by a battery to a circuit of steady resistance. When applied to patients they call it galvanization.

460. Is there any difference between the current obtained from a dynamo and that from a battery of equal voltage?

Current from a battery is steady while there is a slight pulsation in the current obtained from a dynamo even if it be a direct current machine.

461. What is a sinusoidal current?

A sinusoidal current is a common variety of alternating current in which the current gradually increases from zero to a maximum value, then becomes weaker until it reaches zero, then changes direction and rises gradually to a maximum and so on.

462. What is a pulsating current?

A pulsating current goes always in the same direction, but changes its strength, not necessarily falling to zero, but rising and falling by regular gradations.

463. What is an interrupted current?

One that has nearly constant strength, but one that is off and on at regular intervals.

464. Is there any analogy between the flow of electricity and the flow of water?

The number of amperes in an electric circuit corresponds closely to the number of cubic feet or gallons per minute flowing through a pipe. The electric pressure or voltage corresponds closely to the number of pounds pressure per square inch. The electrical resistance corresponds to some extent to the friction along the surface of the pipes, the difference being that the resistance to the flow of water depends upon the surface of the pipe rather than upon its area. The fall of potential, or "drop," due to the passage of current through a conductor equals the product of current by resistance; this corresponds to the loss of pressure in a pipe, which is proportional to the surface friction of the pipe and to the amount of water flowing. The pump and the dynamo are analogous, while the water motors correspond to the electric motors or lamps. Sometimes water motors are arranged tandem so that the same water passes through two or more; such an arrangement corresponds closely to a "series" electric circuit. Generally the water motors are arranged so that each takes its own water and receives the full pressure on the mains; this corresponds closely with "multiple arc" electric circuits such as used for motors or incandescent lamps.

465. Is there any definite direction to the flow of an electric current?

The magnetic and chemical effects of the current show a directionality. Scientists have agreed to say that a current flows in one direction when certain effects appear and to say it flows in the opposite direction when these results are reversed; but it is not certain that what is called positive may not actually be negative. By common consent a current acting in a certain manner is said to flow in a given direction, the point from which it flows being called positive and that to which it flows being called negative. This is somewhat analogous to what is called down and up in relation to gravity, although it is not absolutely certain whether a body falls to the ground because it is pulled by the earth or whether it is pushed by some force from outside.

466. How can the direction of a current be determined from its magnetic effects?

If the current is of considerable strength, its direction may be shown by a compass needle or by a small magnet suspended by a thread or fine wire. Place the conductor so that its direction is approximately north and south, hold the magnet or compass just above the conductor and let the observer face the north. If the north-pointing end of the magnet is deflected to the right, the current is going away from the observer; while, if the south-pointing end is deflected to the right, the current is coming toward the observer.

467. How can the direction of the current be determined by its chemical effect?

In a glass containing water acidulated with sulphuric acid (ten parts water, one part acid), place two pieces of clean lead and connect the same to the two poles of the dynamo, putting an incandescent lamp in series as suggested in the figure. The surface of the lead connected to the positive pole will become reddish brown after the current has passed for a short time, and the surface of the other piece will assume a grayish color. This method may be applied to dynamos for incandescent lamps and for charging storage batteries, but is not suitable for arc machines except by changing the connections. For testing the direction of current from an arc dynamo, the lead cell with the incandescent lamp may be connected in shunt around an arc lamp. The simplest method, however, of testing the direction of current from an arc dynamo is to notice the carbons immediately after the current has been cut off from an arc lamp, when the positive carbon will be found to be much hotter than the negative carbon.

468. What solution is used for moistening the paper in polarity indicators?

The simplest solution is iodide of potassium dissolved in water; when paper is moistened with this and the terminals of a battery or dynamo are connected to it, a brown spot is left at the positive terminal, or where the current enters. The paper must be damp when the test is applied. Adding glycerine to the solution keeps the paper moist longer. On paper moistened with a solution of iodide of potassium to which some starch water has been added, a blue mark is left at the positive pole. Another solution is made by dissolving 15 grains of red iodide of mercury and 20 grains of iodide of potassium in one fluid ounce of glycerine; this must be used moist, keeping the terminals one inch apart for each one hundred volts; a yellow mark is left at the negative pole. By using a solution of ferrocyanide of potassium and iron terminals, a blue mark is left at the positive pole.

In applying any of these tests it is desirable to avoid all risk of making a short circuit. For this reason it is common to place an incandescent lamp in series with the test paper.

Queries and Answers

Is it practical to run wires for frictional electric gas-lighting machines in iron pipes or conduits? L. H. B.

Yes. The wires should be thoroughly insulated with rubber and an outside cotton braid.

What composition is used to repair broken rubber jars? C. D.

There is no composition which can be relied upon to repair broken vulcanized rubber. The best method is to get a new jar.

Can the porous cups and carbons of Leclanche batteries be renewed? If so, how? W. S. T.

Boil the carbons and cups in water for five or ten minutes, being careful to use separate and perfectly clean water for each carbon and cup.

How can I tell when a storage battery is being overcharged? G. S. H.

Under such condition the electrolyte boils vigorously. Up to this point small bubbles merely form on the surface, but there is no definite boiling until overcharging begins.

What is the object of having end play in dynamos and motors? M. A. S.

The object is to insure the proper lubrication of the bearings and also to distribute the wear on the commutator and keep the brushes from wearing grooves in its surface.

What is the strength of the current used on the Atlantic cables? A. D. I.

The strength of the current varies considerably from end to end of the cable. It may be as much as an ampere at the sending end and dwindle down to a milliampere at the receiving end, this dwindling being due to the condenser effect of the cable. The e. m. f. used on the Commercial cables is 40 volts.

Does an incandescent lamp require more current toward the end of its life than at the beginning? R. L. T.

The resistance of an incandescent lamp filament increases very slightly toward the end of its life so that the amount of current taken is a trifle less than that passed by the filament in the early stages of its existence, the e.m.f. at the terminals being assumed constant.

I have built a small dynamo modeled after the Crocker-Wheeler motor, but it will not excite. The magnet cores and yoke are cast iron, made in one piece; the armature is a gramme ring four inches in diameter, and the air gap is three-eighths of an inch from the armature core to the pole face. What is the trouble? D. S. H.

The trouble is that your air gap is too long and the material in your field magnet is too poor. It is difficult to make a small dynamo excite even when the best material is used in the field magnet, and it is impossible when the air gap is long and the field magnet is of poor magnetic material.

What is the best method of regulating the speed of a series motor? W. E. H.

If the motor operates on a constant-potential circuit the most efficient method is to vary the field strength and resistance by cutting in and out sections of the field winding and grouping them in various combinations. The simplest method is to use an ordinary rheostat in series with the motor.

How can I estimate the lifting power of an electromagnet? E. M.

The number of pounds that an ordinary electromagnet will raise may be approximated by multiplying the square inches of contact surface by 35. This rule is based upon a magnetic density of 51,000 lines per sq. in. at the pole-faces. The ampere-turns in the coils must be 20 per inch length of magnetic circuit, for commercial wrought-iron cores, yoke and armature.

What does the word "inches" mean in connection with a vacuum? G. E. E.

The word "inches" is used in connection with a vacuum because when the vacuum gage registers 25, for example, the difference between the pressure within the vessel and the atmospheric pressure on the outside of it is that which would be exerted by a column of mercury 25 inches high. A vacuum of 25 inches, therefore, means a negative pressure or suction equal to that which would be exerted by a column of mercury 25 inches high.

What regulates the e.m.f. and charging current of a storage battery? W. D. S.

The e. m. f. applied to the terminals of a storage cell must be a trifle greater than the back e. m. f. of the cell itself, which ranges from 1.8 volts up to 2.3 volts according to the condition of the cell. When a cell is discharged its e. m. f. is the lower figure and increases from that up to about the higher one at full charge. The charging e. m. f. should, therefore, be from 2.3 to 2.5 volts according to the amount of charging current the battery will stand. This amount is about .06 ampere per square inch of positive plate surface, counting both sides of all of the positive plates.

On page 138 of the March issue, in the description of a double-current machine, the ratio of alternating-current e. m. f. to direct-current e. m. f. is given as .707. If this is correct why will not a rectifier supplied with alternating current at 106 volts deliver direct current at approximately 150 volts? F. M. V.

This depends upon what kind of machine is used as a rectifier. If it is a rotary converter, such as the machine to which you refer, then 106 volts at the alternating-current side will give approximately 150 volts at the direct-current side. If a simple rectifier is used, however, the ratio of alternating-current e. m. f. to direct-current e. m. f. is greater, being approximately .909, so that in order to obtain 150 volts at the direct-current side the alternating-current e. m. f. must be about 141 volts.

What is the difference between direct, continuous and pulsating currents? J. B. C.

All three of these come under the one head of "unidirectional," that is to say, they never reverse in direction. The terms "direct" and "continuous" are used interchangeably to describe this class, but "direct current" is the preferable term because the only current which is actually continuous is that given by a battery. The term "pulsating" is usually applied to a current which fluctuates in strength but does not change in direction. An alternating current is also, however, a pulsating current, because its strength fluctuates, but it is not customary to so designate it.

(1) What is the rated voltage of a spark one inch long in air, from an induction coil? (2) Can the secondaries of two twin induction coils be connected in series when their terminals are separately excited; will the voltage be doubled? Q. T.

The appended table gives the sparking distance in air between needle points for various effective alternating-current voltages.

Effective E. M. F.	Inches.	Effective E. M. F.	Inches
5000	0.225	40,000	2.45
10,000	0.47	45,000	2.95
15,000	0.725	50,000	3.55
20,000	1.	60,000	4.56
25,000	1.3	70,000	5.85
30,000	1.625	80,000	7.1
35,000	2.	90,000	8.35

(2.) The secondaries of two similar induction coils will not work satisfactorily in series if their primaries are separately excited because it would be impossible to adjust the vibrators in unison. If the primaries are connected in series and one of the vibrators is short-circuited, allowing the other vibrator to act for both primaries, then the secondaries of the coils may be connected in series and the voltage will be doubled.

How can I make blue prints, and what apparatus is required? W. O.

In order to make blue prints of drawings you only need a photographic printing frame the full size of the drawing and a supply of blue-print paper, which you can procure from any stores where photographic supplies are sold. Put the drawing in the frame, face downward, that is to say, with the face next to the glass; on the back of this lay the blue-print paper with its blue side down, then put the back on the frame and lay it face up in the sunlight. In order to secure good results the exposure should be continued from five to ten minutes, according to the brightness of the sun. You can tell when the print is completed by lifting the small "peep" panel in the back of the frame and turning up one corner of the blue-print paper until you can see the lines. When the lines on the blue-print paper are almost closed up and look as though the paper were spoiled the print is finished. In order to fix the print take the paper out of the frame and lay it in a basin of clean water until the lines come out good and clear, then put it between two sheets of blotting paper and press it.

SOME NEW FAN MOTOR FEATURES AND SUGGESTIONS FOR FAN MOTOR TESTING.

The Western Electric Company has taken special pains in developing its line of fan motors for 1900, and the following features, which were crowded out of the fan motor article last month, are among the additions and improvements that have been made. A new type has been added, called "Zero" motors. These motors are the same as the regular Western Electric desk and bracket motors, except that the finish is less expensive, and the speed-regulating rheostat is left off. They have the same efficiency and the same high quality of workmanship on the working parts as the more expensive machines, and a motor or wall rheostat can be supplied for regulating the speed as an extra, if desired.

The single horseshoe type of field magnet is used for these motors, as it readily lends itself to completing a graceful general appearance, besides offering advantages in respect to combined high efficiency and lightness of weight. The moving parts are encased by the bearing brackets except at the small openings at the bottom and around the brush holders to permit the ready observation of the condition of the brushes and commutator, so that if anything happens to the motor, sparking will not be concealed until considerable damage has been done. The field coils are surrounded by substantial spools, which protect them from external injury.

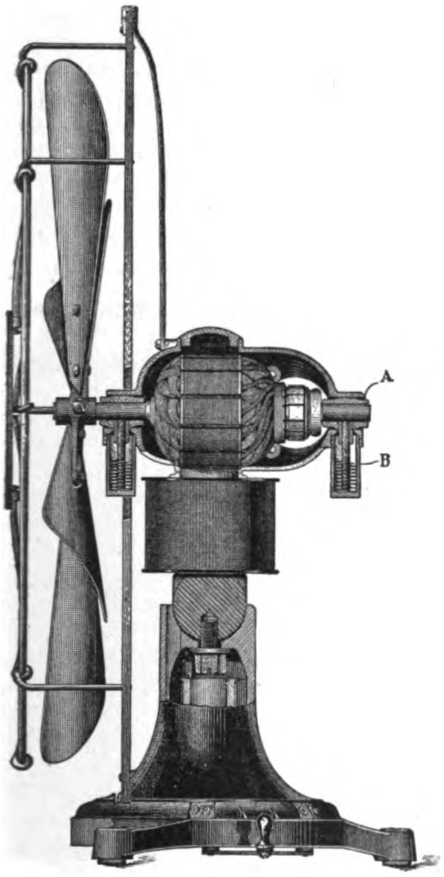

FIG. 1.—ZERO DESK FAN MOTOR.

Babbitt-metal bearings have been adopted for all motors. The makers state that this decision was reached after several years' trial of a number of other metals, and that the babbitt metal consumed the least power in friction; it is further stated that the hard metal now used wears longer than any of the other metals tried. As shown clearly by Fig. 1, the oil cup in the 1900 desk motors is screwed directly in the bearing bracket, so that if the motor is lifted by the cup, no injury can be done to the bearing sleeve. The oil wick enters the journal through a small tube which holds the bearing sleeve in place. This tube can be removed with a screw driver when it is desired to renew the bearing.

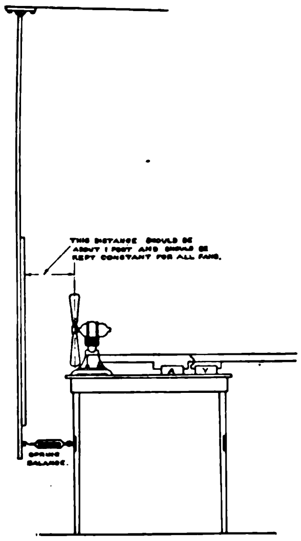
THIS DISTANCE SHOULD BE ABOUT 1 FOOT AND SHOULD BE KEPT CONSTANT FOR ALL FANS.
A
V
SPRING BALANCE.

FIG. 3.—OUTFIT FOR TESTING THE APPROXIMATE EFFICIENCY OF DESK FANS.

The Arctic ceiling fan motor, which was made only for 110 volts last year, is now wound for all the other voltages. This motor, as well as the others, is arranged so that all the external parts are either of solid brass or copper, or else heavily enameled, so that in damp climates rust will not affect the appearance after a year or so.

The switch handle and mechanism of the Standard ceiling fan motor have been made more substantial, so that if the motor is accidentally supported on the handle there is not likely to be any damage to the motor except to the handle itself. The form of construction used in this motor is admirably adapted for obtaining high efficiencies and at the same time furnishing a convenient support for the switch and chandelier. It is also such that any magnetic pull on the armature is transmitted directly to the magnet frame by the bearing brackets at each end of the armature. As the internal strains are so directly taken care of, it is possible to run this chandelier fan with an unusually small air-gap without a corresponding increase in the danger of actual contact. In such slow-running motors this feature is of considerable advantage, as it is an important element in determining the efficiency of the motor. The upper bearing bracket, F, Fig. 2, is made separate from the cover, so that the motor may be set up and handled conveniently as a unit, while the stem and cover are taken off.

The Western Electric Company has for several years been strenuously advocating high efficiency for all types of fan motors, maintaining that efficiency is probably the next most important item after reliability and durability are considered. To consumers paying high meter rates, the efficiency is even more important than durability. The Western Electric Company, in conformity with the above mentioned policy, has made very exhaustive efficiency tests, both to determine the efficiency of the motor and the efficiency of the fan blades. For example, fans of a good many different pitches and curvatures, including helical fans, were tried on desk-fan motors. Fans having enlarged portions at various parts were also tried, and the blade finally adopted was decided upon as combining the greatest number of advantages. The same series of tests was gone through in determining the angle and shape of the ceiling-fan blades. The determinations of the horse-power consumed by the moving air were made by means of an anemometer, suitably corrected for atmospheric conditions.

Curves were then plotted, showing the relation between the horse-power delivered to the fan blades and the horse-power in the moving air. The inter-relations of the speed, pitch, shape of blades, etc., were then adjusted so as to come as nearly as possible to the maximum points on the curves.

Of course it would be highly advantageous to central station managers if anemometer tests of the various makes of fan motors could be made right in the station, but such tests are expensive and tedious. As a fairly sufficient substitute, the Western Electric Company suggests the method indicated in the accompany-

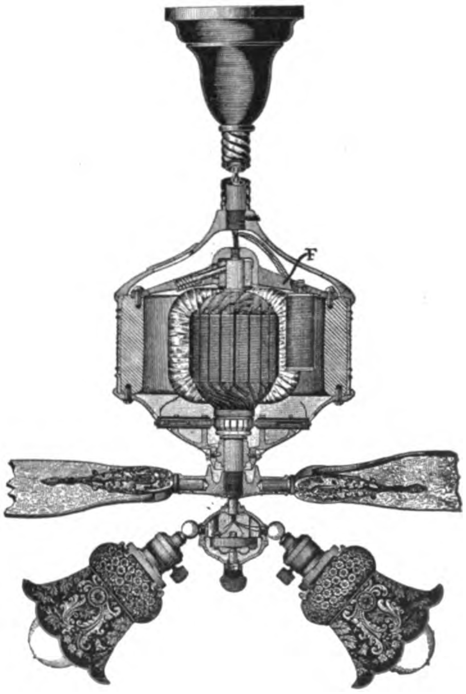

FIG. 2.—W. E. STANDARD CEILING FAN.

ing engravings. This method consists in mounting a paper screen on the ends of pivoted arms in front of the desk fan and underneath the ceiling fan, and measuring the force exerted on these screens by means of a spring balance, as indicated by the accompanying sketches. Fig. 3 shows the arrangement for testing desk motors, and Figs. 4 and 5 are stationary and portable testing outfits for ceiling motors. The distance of one foot between the fan and the screen must be maintained constant for all the motors tested. The screen in the desk-motor tester is four feet square.

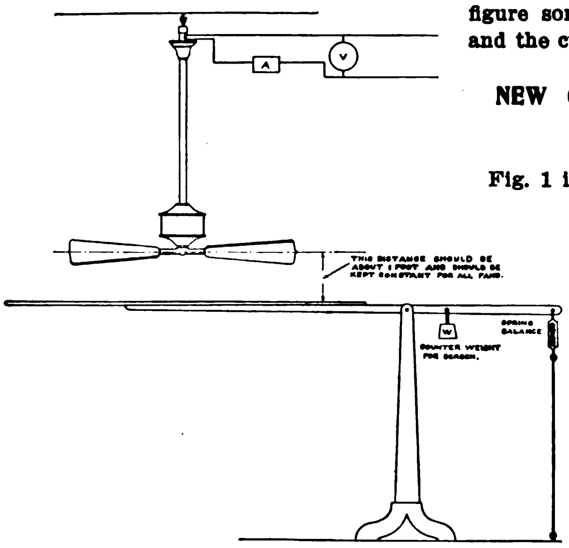
A
V
THIS DISTANCE SHOULD BE ABOUT 1 FOOT AND SHOULD BE KEPT CONSTANT FOR ALL FANS.
W
COUNTER WEIGHT FOR SCREEN.
SPRING BALANCE

FIG. 4.—OUTFIT FOR TESTING CEILING FANS.

The ratio between the pull on the spring balance and the input of the motor in watts is a fairly good basis of comparison, but for accuracy, the force of the screen should be raised to its 1.5 power*, which is readily accomplished by means of a table of square roots. Thus, multiplying the spring-balance pull by its square root gives the 1.5 power of the pull. For the convenience of those wishing to use this method a table of 1.5 powers is presented herewith. As the pull is usually less than a pound, it is expressed in ounces, and the 1.5 power is, of course, that of the ounce value:

Table of 1.5 Powers.

Pull in ounces.	1.5 Power.	Pull in ounces.	1.5 Power.
4	8	12	41.57
5	11.18	14	52.38
6	13.7	16	64
7	18.52	18	76.37
8	22.63	20	89.44
9	27	22	103.19
10	31.62	24	117.58

Desk-fan motors may be compared approximately by placing the same fan on different motors. It should be remembered in making such comparisons, that the horse-power required to move the air is theoretically proportional to the cube of the number of revolutions of the fan blades if the latter had 100 per cent. efficiency. In actual practice the horse-power consumed by a fan is proportional to a figure somewhere between the 2.5 power and the cube of the speed.

NEW CONSTRUCTION IN THEATER DIMMERS.

Fig. 1 illustrates a new type of theater dimmer recently placed on the market by the Wirt Electric Company, Philadelphia. The dimmer is of the interlocking type, and suitable for use on either two-wire or three-wire circuits; the plates are all double, the two parts being joined by connectors when used on a two-wire circuit, and these connectors being removed for a three-wire circuit.

If it is desired, the plates may be placed in series to adapt the dimmer for taking care of about one-quarter of its maximum load. The switches are of the laminated brush-contact pattern, securing excellent contact with minimum pressure, and enabling one to operate a large number of dimmers with ease; moreover, undue wearing of the commutator and switch is prevented by this construction.

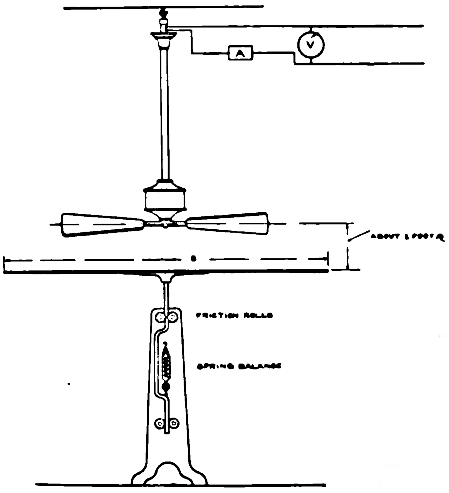

FIG. 5.—PORTABLE TESTING OUTFIT.

The most important feature claimed by the makers of the Wirt dimmer are absence of enamel, which is likely to crack upon the application of a sudden load or heavy overload; absence of a filler, such as sand or cement, which absorbs moisture, and either rusts out the dimmer or permits electrolytic action to destroy it; the use of mica insulation throughout; the absence of small parts, such as nuts, pins, washers and short connecting wires at the contact points; no soldered or twisted joints in the rheostat; direct contact of the resistance with the switch-contact bars; complete encasing in iron, affording ample protection against injury, and offering the utmost active radiating surface; thorough protection of commutator and switch against injury, and a large number of steps, no rheostat having less than 50.

The resistance material is a continuous ribbon wound without break or joint into the desired number of steps, and secured in direct contact with the switch bars without the use of connecting wires, twisted or soldered joints. The amount of resistance is graded according to the ampere capacity desired at each point, and the contact surfaces of the switch connections are also proportioned for the current to be carried. This provides a large switch contact where the current is large, and a small contact where the current is small, in contradistinction to the plan usually followed of using a series of round buttons to carry the current across between the switch and the resistance wires. In the Wirt dimmer a commutator is used, the bars of which progressively vary in size in proportion to the current transmitted. The large number of steps in the dimmer and the careful grading of these also insures that the light shall be dimmed without perceptible "jumps."

The resistance ribbon lies flat against the radiating plates, the only substance intervening being a thin sheet of mica insulation. This construction permits the heat to be most readily conducted to the external surface to be dissipated. The result, it is stated, is tnat the resistance material always runs comparatively cool, a condition which best fortifies it against injury in case of an accidental overload.

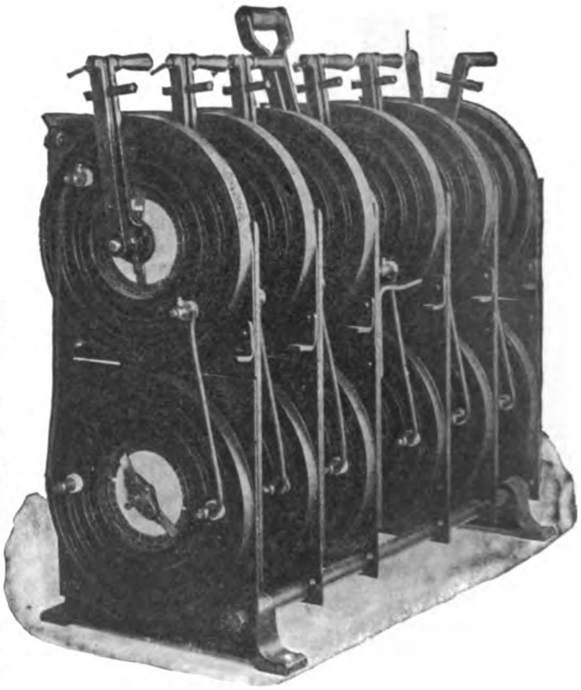

FIG. 6.—WIRT THEATER DIMMER.

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*For the benefit of those interested in the mathematics of the question the following demonstration is given:

P = Power required to move air,
F = Force exerted on screen,
V = Velocity of air,
C and K = Constants.
$P = C \times F \times V$ and $F = K \times V^2$.

Hence $$V = \sqrt{\frac{F}{K}},$$

and $$P = C \times F \times \sqrt{\frac{F}{K}}.$$

Leaving out the constants, which are extremely difficult to determine, P is proportional (not equal) to [illegible] $\sqrt{F}$, which is identical with $F^{1.5}$.

The constants in C and K vary with the height of barometer and the amount of moisture in the air, so that all comparative tests should be made under the same conditions or else the constants determined. These formulas are not strictly accurate on account of the air passing the edges of the screens.

New Apparatus and Appliances

STANDARD FAN MOTORS.

Figs. 1 and 2 show 1900 models of Standard ceiling fan motors built by The Robbins & Myers Company of Springfield, Ohio. In these fans all of the best features of the company's previous models have been retained, and improvements have been made, principally along the lines of simplicity and increased durability. The motors are all of the iron-clad, bipolar type with re-entrant poles on which the field coils are carried.

The armature is deep-slotted, drum-wound and mounted on a turned steel shaft. The bearings are self-centering, swivel-seated sleeves of anti-friction metal, running in semi-enclosed oil cups which carry a year's supply of oil. The commutator segments are cut from hard-drawn copper bar and the commutator is insulated throughout with pure mica and mounted on a steel sleeve between steel collars. The connecting wires are firmly bound to an asbestos insulating ring on the rear collar and are soldered into slots milled in the corners of the segments. The binding of the connecting wires prevents their being broken by vibration or rough handling, and the milling of slots in the corners of the bars allows the commutator to be made of maximum diameter and doubles the wearing depth of the copper, as compared with the "lug" type of segment.

The brush holders are of the company's new cartridge type, consisting of a thin brass shell held firmly in place by a rigid insulated clamp to which the lead wire is fastened. The cartridge contains a 5/16 in. x 1 in. round carbon pencil fed radially by a piano-wire compression spring. The shell may be removed by the loosening of the clamp screw, bringing with it the brush and spring. The pressure on the commutator is steady, and is said to entirely prevent any sparking due to uncertain brush contact.

The insulating hanger is made of leather which prevents any vibration being transmitted from the fan to the room above, and which is not subject to breakage.

The fans are supplied with speed regulating switch and the resistance coil, which is concealed inside of the motor, is fireproof.

For fans running in series the switch on each fan allows it to be stopped without in any way interfering with the others in the same series. This feature is patented and is peculiar to the Standard fan motors.

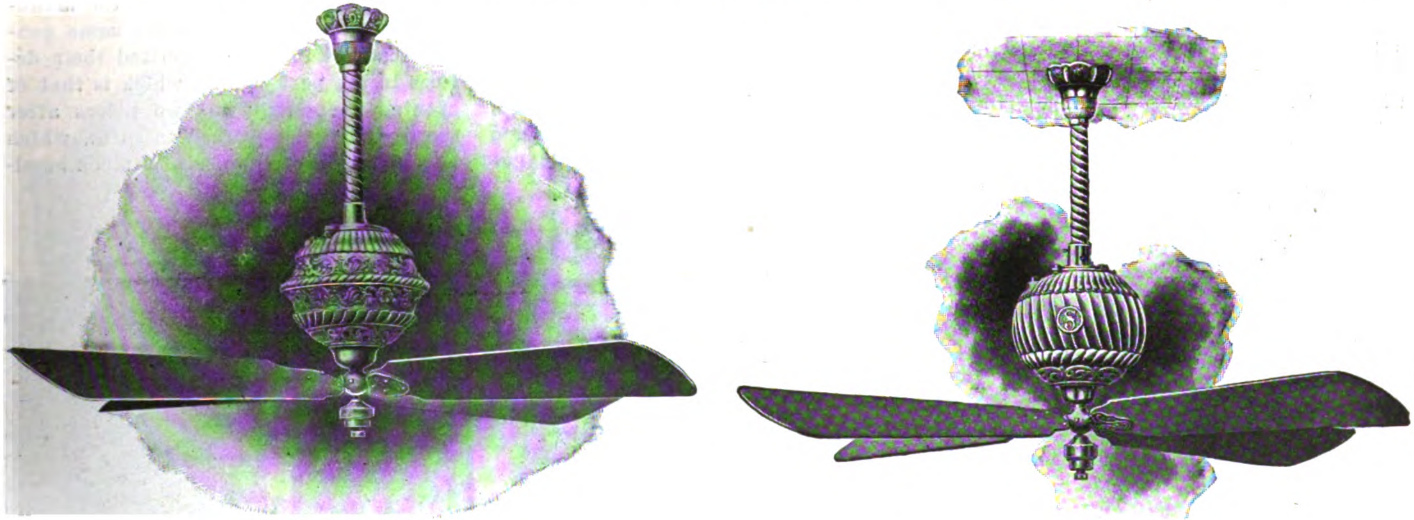


FIG. 1. ROBBINS & MYERS STANDARD CEILING FAN MOTORS. FIG. 2.

IMPROVED "JAGABI" PORTABLE TESTING SET.

While the "Jagabi" testing set, for which Jas. G. Biddle, Philadelphia, is sole agent, has been on the market for several years, the form shown by Fig. 3 is quite new, and a decided improvement upon previous instruments. The rheostat contains 16 coils, ranging in resistance from 1 to 4000 ohms, and having a total capacity of 11,000 ohms. The Wheatstone bridge consists of coils of 1, 10 and 100 ohms on one arm, and 10, 100 and 1000 ohms on the other. A bridge-reversing device enables any ratio to be obtained that is possible with a bridge having coils of 1, 10, 100 and 1000 ohms on each arm. The rheostat coils are guaranteed accurate within one-fifth of one per cent., and the bridge coils within one-tenth of one per cent. The galvanometer is of the d'Arsonval type, which is so valuable because of being unaffected to an appreciable extent by surrounding mechanical or electrical disturbances. Furthermore, it is dead-beat, so that measurements can be made very quickly. A few cells of special dry battery supply necessary current for all ordinary measurements.

Because of the high sensitiveness of the d'Arsonval galvanometer which forms part of the "Jagabi" portable testing set, it is said to be possible to make measurements with the following degree of accuracy:

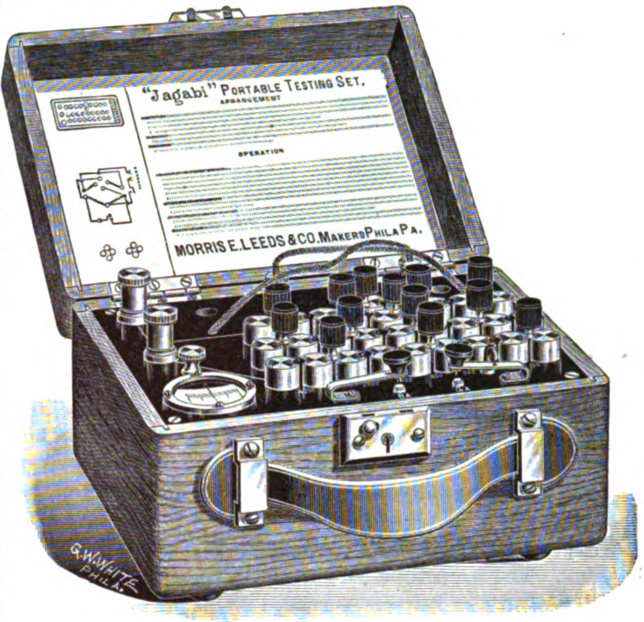

"Jagabi" Portable Testing Set.
Arrangement
Operation
Morris E. Leeds & Co. Makers Phila Pa.
G. W. White Phila.

FIG. 3.—"JAGABI" TESTING SET.

Resistance of about .01 ohm, within 1 per cent. of standard; resistance of .1 to 1 ohm, within ½ per cent. of standard; resistance of 10 ohms to 100,000 ohms, within 1/5 per cent. of standard; and resistance of 1,000,000 ohms, within 3 per cent.

The error of 3 per cent. in measuring resistance of about one megohm can be very much reduced if an auxiliary battery of 50 cells or more is employed. In fact, when making tests between one megohm and 11 megohms, the latter representing the theoretical limit of the apparatus, a battery of 50 or 100 cells should be used, and under such conditions surprisingly satisfactory work can be done. The instrument is mounted in a handsomely finished case, with carrying strap and lock.

SPECIALTY VENTILATING FANS.

The Specialty Manufacturing Company, of Indianapolis, Ind., is manufacturing three types of propeller fans, two of which are shown by the accompanying engravings. Fig. 4 is the Junior water-motor desk fan, designed to be operated by water pressure of 30 lbs. or over. The motor has a ground tool-steel shaft and the journal is provided with a hard brass bushing. The propelling jet is 1/16 in. in diameter and the inlet is threaded to fit the ordinary ¾ in. hose coupling, so that no special arrangement is necessary in order to set up the fan. Ordinary garden hose can be run from the most convenient faucet to the fan, making it practically as portable as an electric desk fan. The motor is enameled in black and drives a four-blade 13-in. fan made of spring brass and nickel plated. The complete equipment weighs 9 lbs.

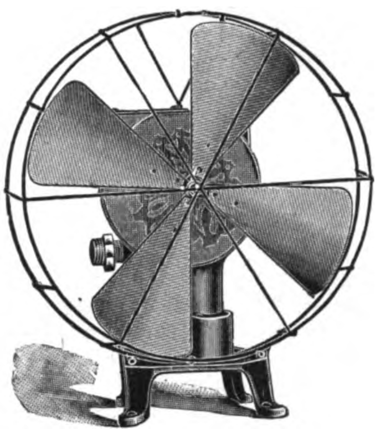


FIG. 4.—JUNIOR WATER MOTOR DESK FAN.

Fig. 5 is the Triumph electric ventilating outfit manufactured by the Specialty Company and comprises an enclosed multipolar motor direct coupled to the fan. As the engraving shows, the motor is mounted on a substantial bracket which is an integral part of the fan framing. This method of mounting is particularly convenient in that it permits the motor to be removed from the fan during periods when the latter is not needed and to be used for other work. The motor is of the most modern type and provided with automatically-fed carbon brushes, self-oiling boxes and a starting rheostat with automatic release. The outfit is made in four sizes, namely, 30 in., 36 in., 42 in., and 48 in. fans. A feature of the fan framing is the flat square back which greatly facilitates the installation of the outfit.

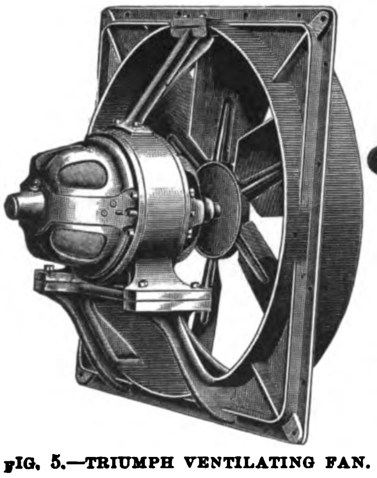


FIG. 5.—TRIUMPH VENTILATING FAN.

The third type of fan, which is not illustrated, is designed to be belt driven by any prime mover. It is similar to the fan shown by Fig. 5, except that in place of a motor a driving pulley is provided. The belted type of fan is equipped with adjustable self-oiling boxes, carrying genuine phosphor-bronze bushings. These outfits range in size from 18 ins. to 96 ins., diameter of fan.

A NEW STORAGE BATTERY GRID.

H. M. N. Muhle, of Dayton, Ohio, has brought out a new form of grid for storage cells, the peculiarity of which lies in the fact that all the positive plates of a cell are in one piece and all of the negatives are likewise integral. Figs. 6 and 6-A show how this is accomplished. The former represents a negative three-plate grid as it comes from the foundry, and Fig. 6-A shows it bent into shape. The positive grid to match this has only the two upper plates, the middle one being omitted. The active material is applied before the grid is bent into working form.

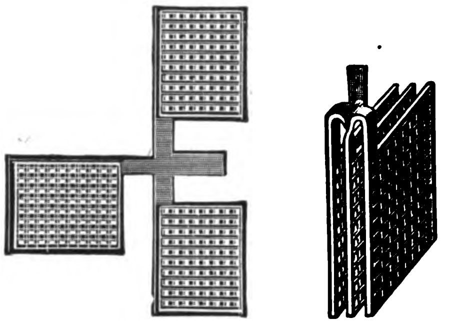


FIG. 6 AND 6-A.—ONE-PIECE STORAGE BATTERY ELEMENT.

The advantage of eliminating the joints between the plates of one electrode is too obvious to require discussion. The maker states that grids are cast with any number of plates per terminal.

GARTON LIGHTNING ARRESTERS.

The season of spring storms being at hand the lightning arrester problem is again disturbing street railway and central station managers. We illustrate herewith some new models of arresters put out this year by the Garton-Daniels Company, of Keokuk, Iowa. Fig. 7 shows a new direct-current pole arrester for light and power circuits of 750 volts or less, with an iron cover, and Fig. 8 shows it with the lid removed. The base and the spool are made of porcelain. The construction of the iron box is such that loosening one screw at the bottom of the box allows the lid to slide upward and be swung to one side for the inspection of the arrester. The same type of arrester is furnished with a wooden cover, made from clear selected stock, with tongue and groove construction at exposed joints; it is provided with sliding lid, with spring catch to allow easy inspection. The arrester with the iron cover weighs eleven pounds. The one with the wooden cover weighs five pounds.

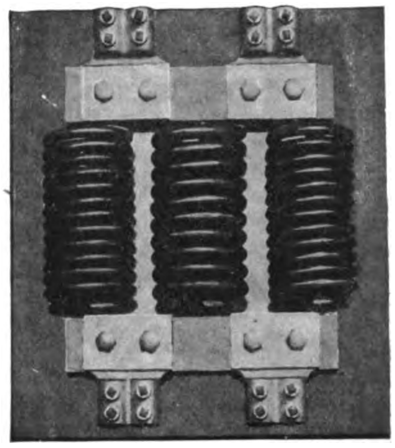
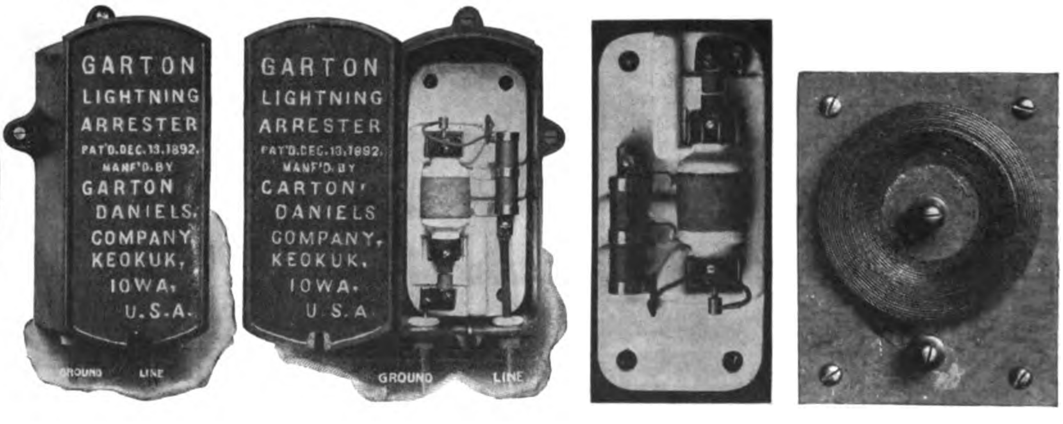


FIG. 11.—1200-AMPERE KICKING COIL.



FIGS. 7, 8, 9 AND 10.—NEW GARTON LIGHTNING ARRESTERS AND KICKING COIL.

In designing the new models the manufacturers have adhered to the same general features that characterized their devices in the past, among which is that of opening the circuit in two places after the discharge has passed to earth, which is said to permit the use of a much smaller air-gap than would be practical were the circuit opened in one place only.

Fig. 9 shows the new arrester for the protection of stationary motors of all sizes, and Fig. 10 is a new kicking-coil known as Type S, for use in conjunction with same. Fig. 11 represents one of a number of 1200-ampere kicking-coils furnished to Siemens Bros. & Co., Limited, of Woolwich and London.

ERICSSON MICROTELEPHONE OUTFIT.

The well-known Ericsson telephones are supplied in American cases and of American patterns by the Ericsson Telephone Company, 296 Broadway, New York, who are the sole agents and representatives for the United States of L. M. Ericsson & Co., Stockholm, Sweden. These telephones are said to give equally good satisfaction in short or long distance work. The transmitters and receivers are very sensitive, transmitting a whisper, it is claimed, just as well, relative, as louder sounds, and for clearness, this instrument is particularly recommended. They require no adjusting and are said to be unaffected by and climate, whether hot or cold, wet or dry. In all cases the genuine imported transmitters and receivers are sold; to exchanges desiring to improve their service the transmitters and receivers are sold separately and can be placed on the instruments now in use.

Fig. 12 shows one of the latest Ericsson instruments, which is made without gravity hook, and which is adapted for either wall or desk use. When used on a desk, the magneto is placed in the usual position under the desk, and the combined transmitter and receiver (known as a hand microtelephone) can either be placed on the flat of the desk, in a pigeon hole, on the top of the desk or hung on the side of it.

When used as a wall telephone, the hand microtelephone can be hung on an ordinary hook and placed at any convenient height. Holding the receiver to the ear brings the transmitter at a proper distance from the mouth, and a switch in the handle, which is naturally pressed by the fingers in grasping the instrument, makes all the connections. When the handle is released the instrument is cut out automatically, as with the gravity hook used with ordinary telephones.

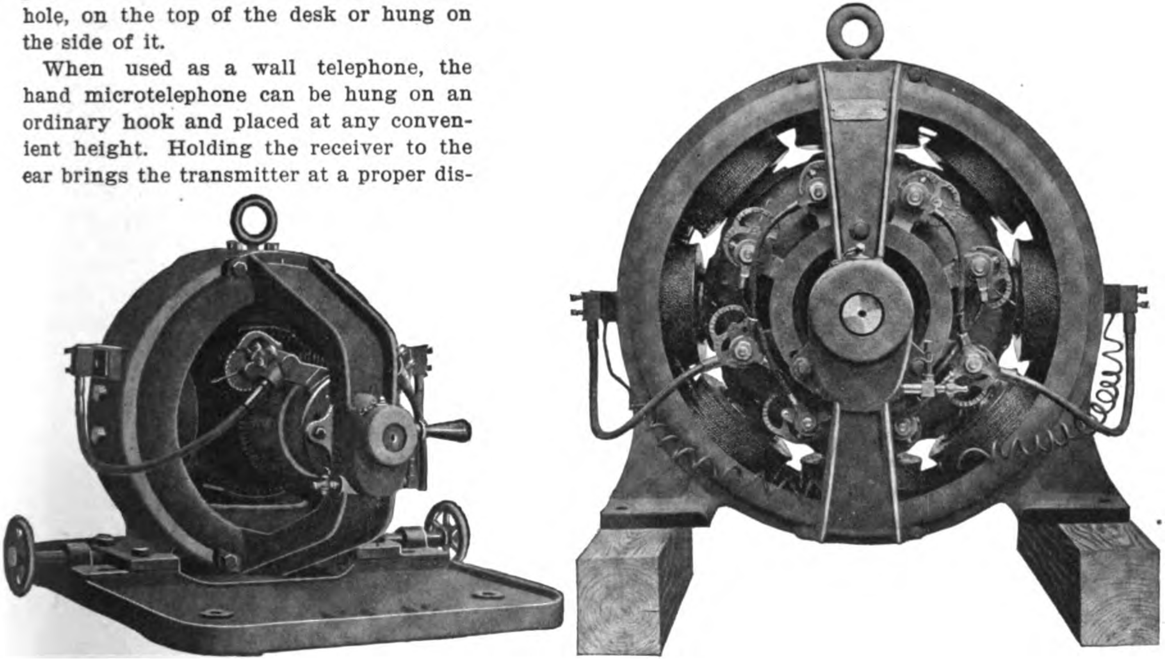


FIG. 13.—C & C DYNAMOS FOR DIRECT CONNECTION.—FIG. 14.

SPECIAL TYPES OF C & C DYNAMOS AND MOTORS.

Figs. 13 and 14 illustrate special dynamo or motor designs recently perfected by the C & C Electric Company, New York City. Fig. 13 is known as Type TB, and is designed for direct-connected service. As the illustration shows, it is a four-pole machine of very compact design; it is built in five sizes, ranging from 2 to 6 h.p. in motors, and 2 to 5 kw. in dynamos. Only two brushes are used, and these are of the standard C & C reaction type. The design shown by Fig. 14 is very similar to the one just mentioned, the chief differences being in the number of poles and number of brushes employed. The field magnets of both machines are of cast steel and the poles are provided with shoes which are bolted on. The eight-pole type is built in six sizes, ranging from 3¾ to 15 kw. dynamo output, or 4 to 18 h.p. motor output. The field-magnet coils are wound on metal bobbins in order to avoid liability to damage from chafing, and are protected by a covering of rope. This type of machine is known as Type PP. The speeds of the four-pole machines range from 450 to 1200 r.p.m., running as motors, and 525 to 1325 r.p.m., running as dynamos. The eight-pole machines operated as motors have speeds ranging from 100 to 675 r.p.m.; running as dynamos, the speeds are from 120 to 750 r.p.m.

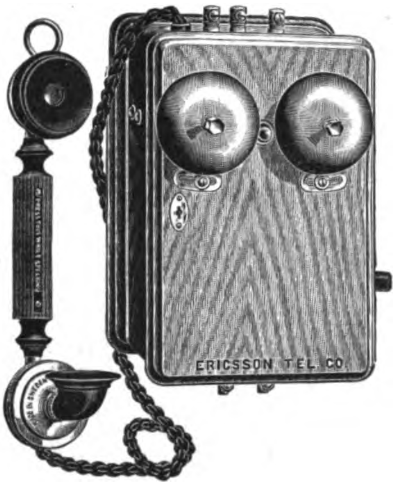


FIG. 12.—ERICSSON MICROTELEPHONE SET.

FEDERAL SALT DRY BATTERY.

The Federal Battery Company, of New York, manufacturer of Federal salt and Federalite for batteries, have brought out a Federal salt non-polarizing dry battery cell of its own. The company states that its new battery has been tested on all kinds of work with the greatest success, especially in telephone service. A report of a special test recently made gives the following data:

A test made with a Ruhmkorff coil and one Federal salt dry cell gave a spark across an air gap of ⅝ inch, while the longest spark obtained with other cells tested was 1/32 inch for a single cell and ¼ inch with two cells in series.

In another test of four Federal salt dry cells in multiple series, the circuit was broken 68 times a minute for 23 hours, 9 hours one day and 14 hours the next day. The coil was adjusted so that the length of spark was ⅝ inch. During the entire run, it is stated, some 97,000 sparks were thrown across this gap without a single failure, and at the end of the test the e. m. f. showed no preceptible drop. In telephone service, it is said, these cells have been used over 50 times a day for more than three months and after resting over night, the e. m. f. came up to 1.4 volts.

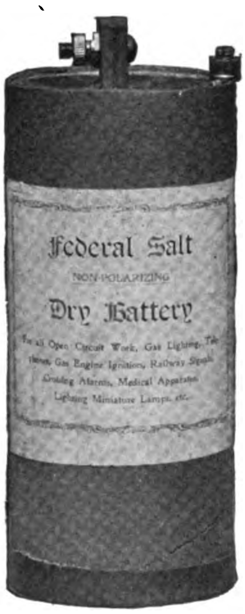


FIG. 15.—FEDERAL SALT CELL.

THE "WOOD" IMPROVED ARC-LAMP CLUTCH AND ADJUSTABLE TRIP.

A new arc-lamp clutch and adjustable trip, used by the Fort Wayne Electric Works, Fort Wayne, Ind., is represented by Fig. 16. The operation of this clutch, it is said, is not affected by the condition of the rod. The body of the clutch does not fit the rod closely, but only at the extreme ends, where there are curved surfaces which impinge upon the rod at intervals of 120 degrees, the rod being held against them by the pivoted shoe, which has a long gripping surface. Thus, if the rod should become extremely dirty, it will still feed properly because of the large area of the gripping surfaces of the clutch. It is claimed that even dents or lumps on the rod will not affect the action of the clutch.

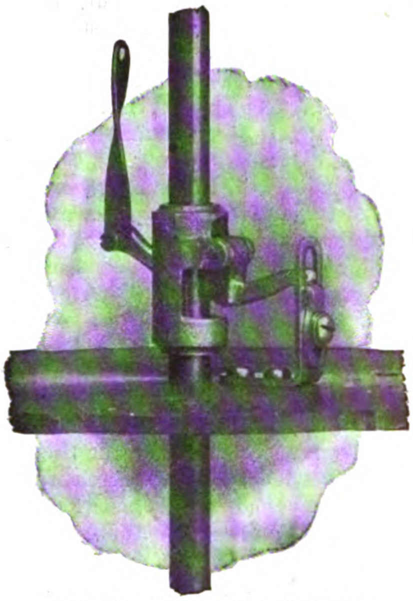


FIG. 16.—NEW WOOD CLUTCH.

These clutches are made right and left-handed for the double-carbon clutch Wood arc lamps, the right-handed clutch being also used for the single-carbon lamps. In order to fully meet the requirements of modern arc-lamp service the adjustable trip feature was devised. By means of this the length of the arc may be adjusted to a nicety.

A NEW WALL INSULATOR PIN.

An ingenious pin for securing porcelain insulators to brick walls has been designed by Dr. Alfred Muller, 132 Nassau Street, New York. Fig. 18 shows the pin and a porcelain knob, separated, and Fig. 17 shows them screwed together. The pin is made of a non-oxidizable metal or alloy of metals; it is provided with an ordinary screw-thread at one end for holding the insulator, and its main body is formed with angular or ratchet grooves. This portion is put in a hole pierced in a wall and secured therein with cement or any other suitable material, the screw-threaded portion, of course, projecting. As this latter portion is threaded to engage with an internal screw thread in the center of the insulator, the latter is simply screwed upon the threaded end of the pin which projects from the wall.

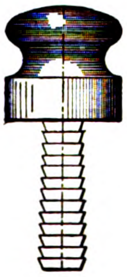
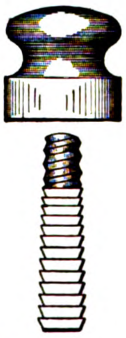



FIG. 17.—INSULATOR PIN.—FIG. 18.

The insulator is thus put up without the use of a special screw, so that there is not only saved the usual iron screw, which oxidizes and thereby affects the insulator, but also considerable time; moreover, when the stem is once fastened in the wall, it is perfectly secure against loosening.

MULTIPOLAR DYNAMOS WITH POSITIVE OIL CIRCULATION.

Small dynamos and motors occasionally get themselves and their owners into trouble by reason of defective oiling arrangements, or normally effective oilers which hang up unaccountably, it may be. In order to guard against this sort of annoyance, Bartz, Evans & Wygant of Hornellsville, N. Y., equip their machine with a pumping arrangement driven from the commutator end of the dynamo or motor shaft, as shown in the accompanying illustration. This device provides a continuous and positive circulation of oil through the bearings while the machine runs, eliminating all liability of annoyance due to hardened wicking or slipping oil rings.

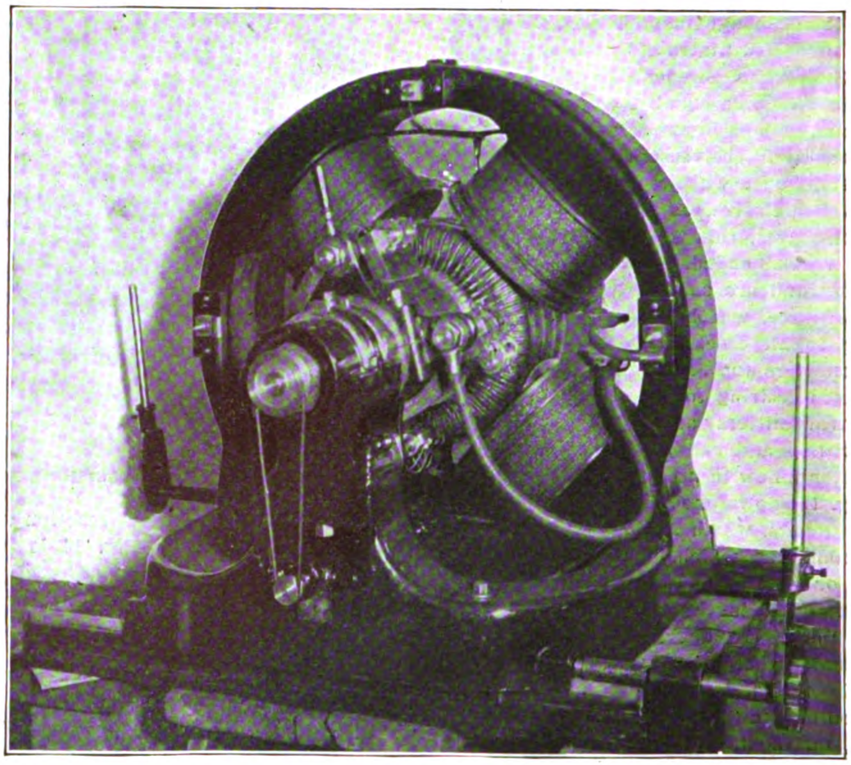
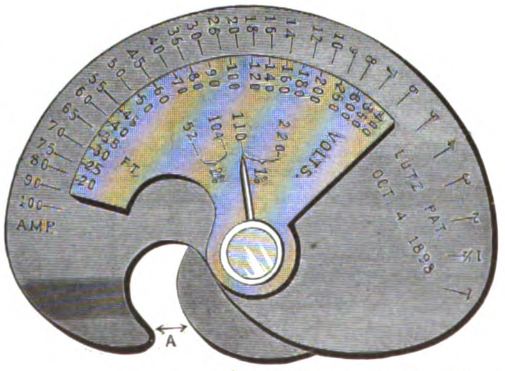


FIG. 19.—DYNAMO WITH POSITIVE OIL FEED.

The machine itself is provided with a well-ventilated armature, gramme-wound, and having the core keyed to the shaft. The brushes are of carbon, tangentially applied. The field magnet is of cast steel, and is a single casting.

A NEW WIREMAN'S CALCULATING GAUGE

The United States Wireman's calculating gauge, illustrated by Figs. 20 and 21, is designed to enable the wireman while at work to instantly determine the proper size of wire to use on any main or feeder.



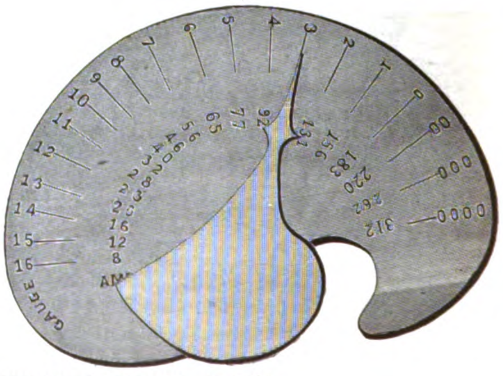


FIG. 20.—GAUGE FOR CALCULATING WIRING.—FIG. 21

The operation of the gauge is so simple that any one can use it. All that is necessary to know is the distance in feet from the fuse block to the center of distribution, the number of amperes that the

American Electrician.

Vol. XII. New York, June, 1900. No. 6.

THE POWER GENERATING PLANT AT THE PARIS EXPOSITION

COMPRISING TYPICAL EXAMPLES OF EUROPEAN ENGINEERING.

On account of the natural adoption of electrical power transmission for the Paris Exposition, it has been possible to concentrate the whole of the power plant for the main buildings in two central stations under the roof of the Electricity Building. These are known by the names of the streets which bound the Champ de Mars on the east and west, as the Bourdonnais station and the Suffren station; also by the designation of French and Foreign stations, respectively, as in one case both boilers and generating machinery are furnished by French manufacturers, and in the other by exhibitors from different countries. These two stations are entirely distinct, one from the other, with separate systems of boiler flues leading to ornamental chimneys, but a complete arrangement of underground steam and water mains unites them.

The boiler rooms are located between the old Galerie des Machines and the new Palace of Electricity, in which are installed the large direct-connected engines and dynamos which furnish current for distribution of light and power throughout the Exposition grounds. The boiler rooms are built with open sides and a steel frame roof, covered with corrugated iron with a glass skylight, leaving a clear space next to the adjoining buildings of about 18 ft., and conforming thereby to the French law which regulates the use of boilers in proximity to inhabited buildings, under which category the Exposition structures are included. This space is used, however, for the passage of cars conveying coal or removing ashes, for storage of coal, and as a means of circulation. It is of interest to note that such care is taken to avoid the flying in the air of dust or ashes that both coal and ashes are required to be handled in sacks for transportation within the Exposition precincts, and all such work must be concluded before eight o'clock in the morning.

Each boiler room covers an area 344 ft. long and 92 ft. wide, the clear height at the center being 24 ft. 7 ins., and the boilers are arranged in two rows, back to back, the lines of fronts being kept straight. The engines to be supplied from these boilers being of about 36,000 horse-power, a steam capacity of about 518,000 pounds per hour has been provided, the Bourdonnais station supplying slightly more than one-half of this amount. The maximum demand is considered as not ex-

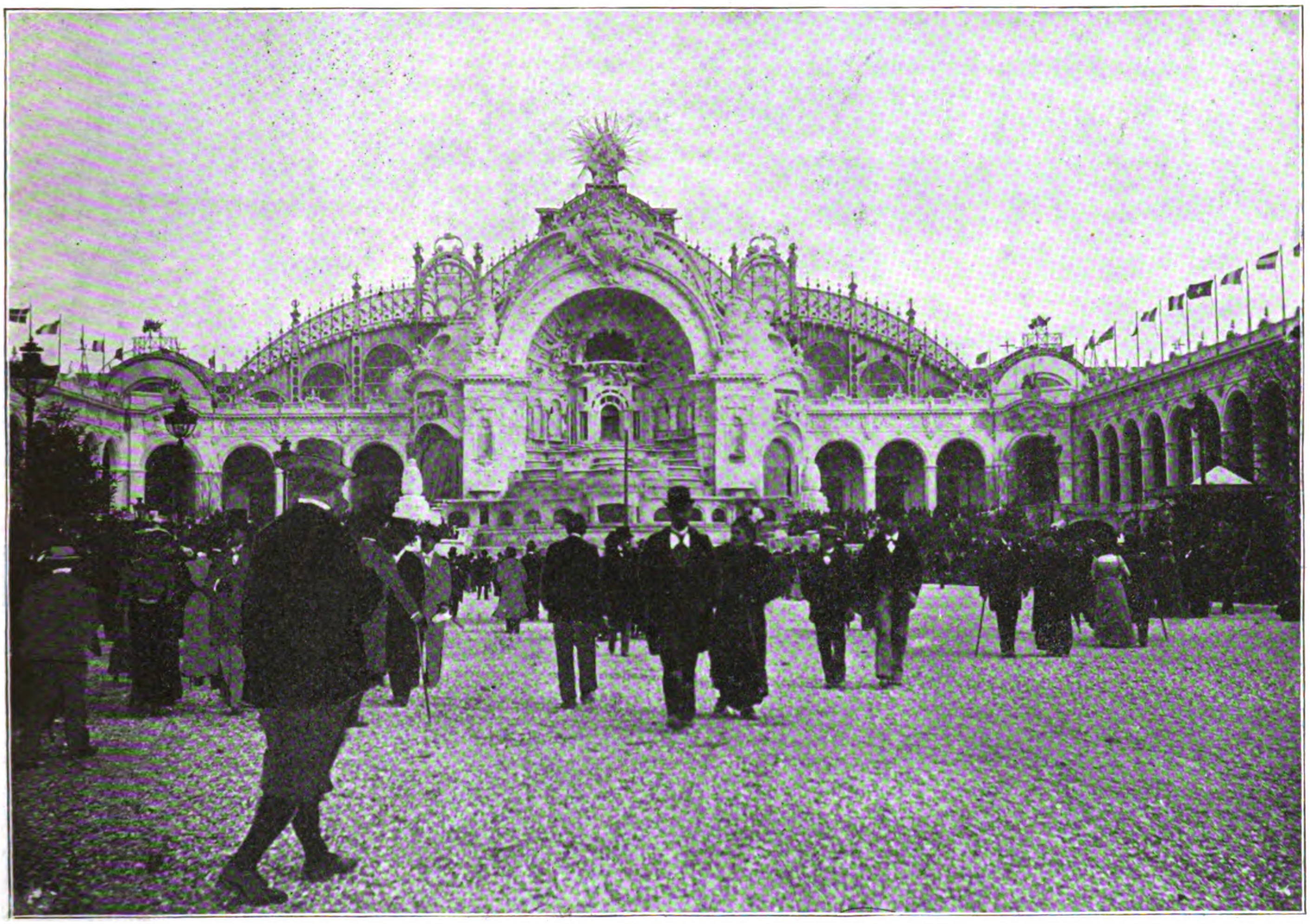


FIG. 1.—VIEW OF ELECTRICITY BUILDING AND CHATEAU D'EAU, TAKEN FROM THE EIFFEL TOWER.

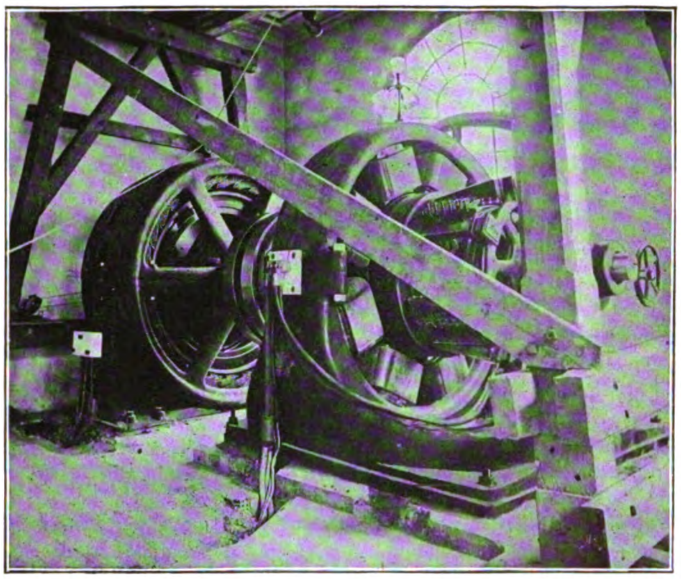


FIG. 2.—ONE OF THE MOTOR-GENERATORS WHICH DELIVER DIRECT CURRENT FOR THE MOVING SIDEWALK MOTORS.

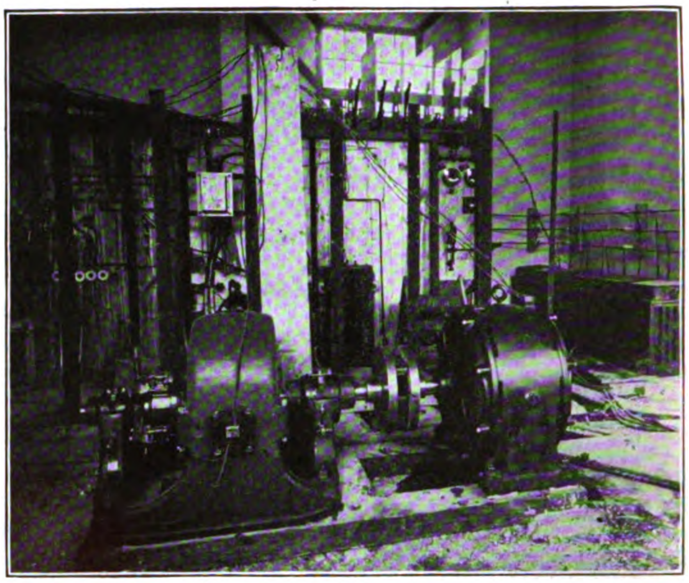


FIG. 3.—AUXILIARY EXCITER AND STARTING OUTFIT FOR THE MOTOR-GENERATOR OF MOVING SIDEWALK EQUIPMENT.

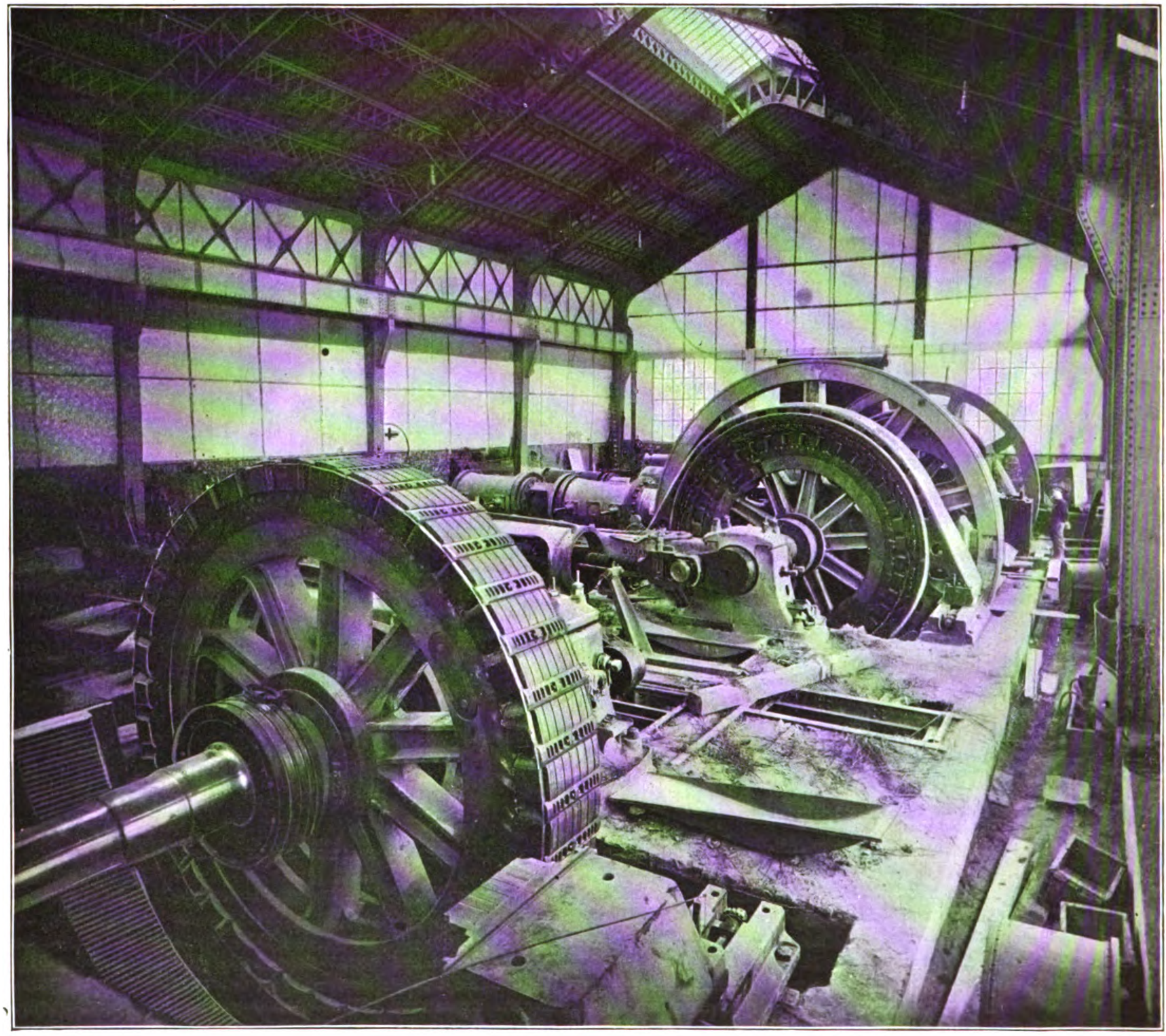


FIG. 4.—A VIEW OF THE INTERIOR OF THE MOULINEAUX POWER HOUSE, SHOWING WESTINGHOUSE GENERATORS IN PROCESS OF INSTALLATION.

ceeding 440,000 pounds per hour, leaving a margin of 78,000 pounds, which will assure an uninterrupted service, even though some boilers are disconnected for cleaning or repairs. One day a month is allowed each boiler for cleaning, this being judged sufficient by the administration authorities, who have taken the precaution of requiring that no type of boiler shall be admitted which has not already stood the test of practical use under the ordinary outside conditions of everyday working.

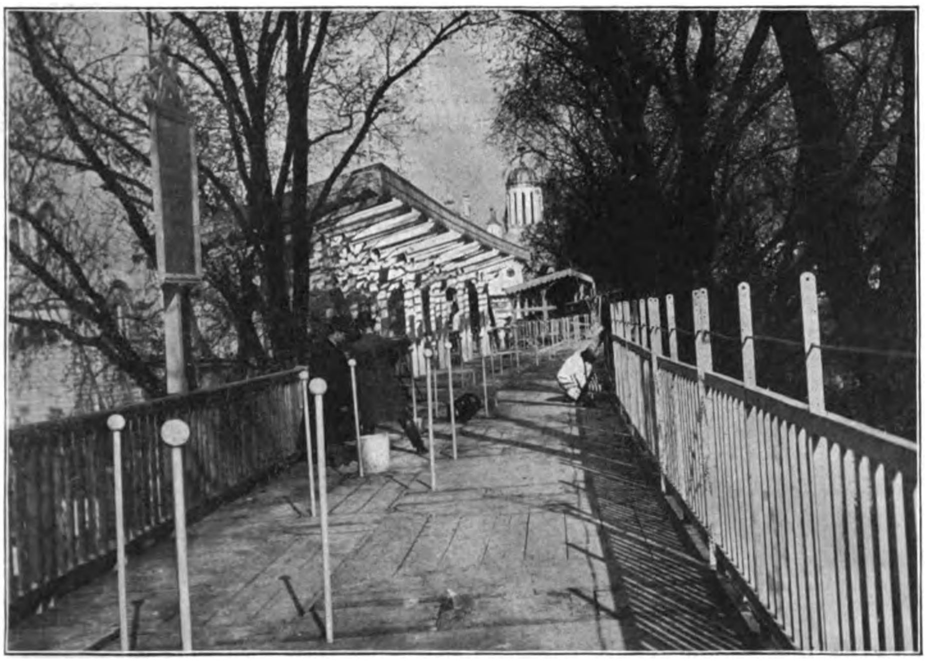


FIG. 5.—SECTION OF TRAVELING SIDEWALK.

There are 92 boilers in the two stations, most of which are of the water-tube type; a few are of the Lancashire or Cornish internal fire-tube type. The total heating surface of the boilers is approximately 160,000 sq. ft., which, considering a maximum steam production of 518,000 pounds per hour, gives an average of 3.2 pounds of steam per hour per square foot of heating surface. The steaming power varies between the limits of 4.73 pounds per hour per square foot with a ratio of heating surface to grate area of 24.1, and 2.056 pounds with a ratio of 55.1. The total grate area is 4240 square feet, giving a steam production of 122 pounds per hour per square foot. The average steaming capacity of the boilers, individually, is about 5600 pounds per hour, but this figure is doubled in the case of a boiler by Mathot, a French manufacturer, who also proposes to supply a boiler of one-half the average capacity. These exhibits are, however, not yet on the ground. Three of the largest exhibitors are represented in both stations: the Babcock-Wilcox Company, of Paris; J. & A. Niclausse, of Paris, and De Naeyer & Co., of Willebroeck, all furnishing water-tube boilers and providing nearly one-half the capacity of the whole plant. The Mathot Company also exhibits in both sections.

The semi-tubular boilers of the company of Fives-Lille are made with two water cylinders below, each connected by three water legs to a single upper boiler provided with fire-tubes for return of the hot gases (Fig. 6). The Cornwall type of boiler, so designated in the official publications, is in reality of three distinct styles. Paucksch has one internal fire-tube; Petzold and Berninghaus have two, with superimposed fire-tube boilers, while a special boiler by the last-named manufacturer has three internal fire-tubes.

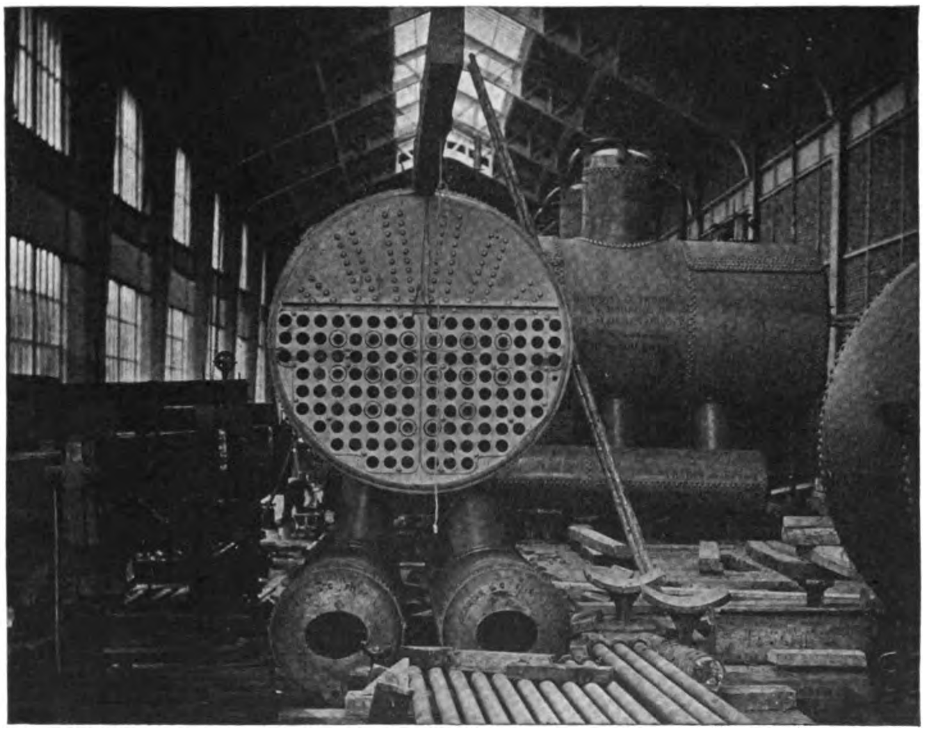


FIG. 6.—FIVES-LILLE BOILERS IN COURSE OF INSTALLATION IN THE MOULINEAUX STATION; SHOWING ARRANGEMENT OF WATER DRUMS.

The steam pressure at the boilers is to be 156 pounds per square inch, and at the engines 140 pounds. The boilers feed into two sets of 10-in. steam mains carried one above the other on the framework supporting the roof; and cross-connections between the lines on each side are made, bringing the steam to two equalizing cylinders about 28 ins. in diameter and 10 ft. long, situated 120 ft. apart. From each of these cylinders four 10-in. pipes convey the steam through large brick tunnels to the engine rooms.

Feed water for the boilers is supplied by the administration of the Exposition, the upper basin of the Chateau d'Eau—the great fountain in the Champ de Mars—being used as a reservoir from which water is brought to the two lines of boilers in each station, by means of a 14-in. main, feeding into a 10-in. cross line, and terminating in two cast-iron 8-in. pipes. Outlets are provided at convenient points where exhibitors are required to make connections to their pumps at their own expense, using 2 5/16 in. pipe.

The main smoke flues and the chimneys have been built by the Exposition administration, but the communicating flues from the boilers are put in at the expense of the exhibitors. All the construction is underground, in two divisions 300 ft. long, passing through the length of the boiler room and curving outward to right and left at a distance of 62 ft. from the chimney, to enter the base at diametrically opposite points. In order to avoid encroaching upon the foundations of the boilers, the increase in size of consecutive sections of the flues is downward, thus preserving a uniform total width, after the first section, of 27 ft. The first section, in each division, consists of a vaulted brick tunnel 6 ft. 6 ins. high and 3 ft. 10s. wide. The sides, forming the abutments of the arch, are brought up to the level of the top of the arch, in order to form a secure foundation for the railroad tracks passing down the center of the space, and to support the rear ends of any boilers extending so far toward the center.

In order to promote a good draught through the flues and chimney, the individual flues from the boiler groups are curved at the point where they enter the main flues.

Each station has a large ornamental chimney, at the side toward the street, one near Avenue de la Bourdonnais and one near Avenue de Suffren. The height in each case is 80 metres (262 ft. 6 ins.) above the ground, the internal diameter at the top is 14 ft. 9 ins., and at the base 20 ft. 4 ins. The outside diameter at the base, on the ground level, is nearly 40 ft., and at the lowest point, 21 ft. below ground, the foundation is 59 ft. in diameter. The excavation was carried to this depth in order to reach firm soil, as the ground of Champ de Mars has so frequently been disturbed within the last 30 years. Below a stratum of sand, clay was found, of high resisting quality, and to ensure thorough stability a further foundation of 133 piles was used, these being driven till the blows ceased to have appreciable effect. The piles were then cut down to a uniform height of about 3 ft. above the level of the floor of the excavation, and the whole covered with a bed of concrete 5 ft. in thickness, upon which the chimney was subsequently built.

In the interior of the chimney are bars, spaced at every fifth row of bricks, for ascending. As a matter of precaution and to allow of resting during the ascent, a second series of bars encircles the first, forming a sort of cage through which a man can mount with much greater measure of safety than by a single line. The ornamentation of the chimneys is quite elaborate, but not overdone, as a considerable portion of the shaft is left plain. All the decoration is effected by the use of fancy brick and ceramic designs. The Bourdonnais chimney was built by Nicou & DeMarigny, and the Suffren chimney by Toisoul & Fradet.

Owing to the large number of pipes required for distribution of steam and water in the machinery section of the Champ de Mars, it was necessary to employ an underground service. The most practicable method of accomplishing this was to provide subterranean passages or tunnels, where all pipes would be readily accessible for inspection or repairs, and such a system, on a liberal scale, has been carried out. The tunnels are built in three sizes, according to the size of pipes which they are intended to accommodate. No. 1 is 8 ft. 6 ins. wide, 8 ft. 10 ins. high and 1700 ft. long; No. 2 is 7 ft. 10 ins. wide, 8 ft. 6 ins. high and 2400 ft. long; No. 3 is 6 ft. 6 ins. wide, 8 ft. 6 ins. high and 660 ft. long. In addition to these tunnels there are drainage tunnels, carrying no pipes, which take the overflow from both sides of the system at Avenue de la Bourdonnais and Avenue Suffren into the city sewers.

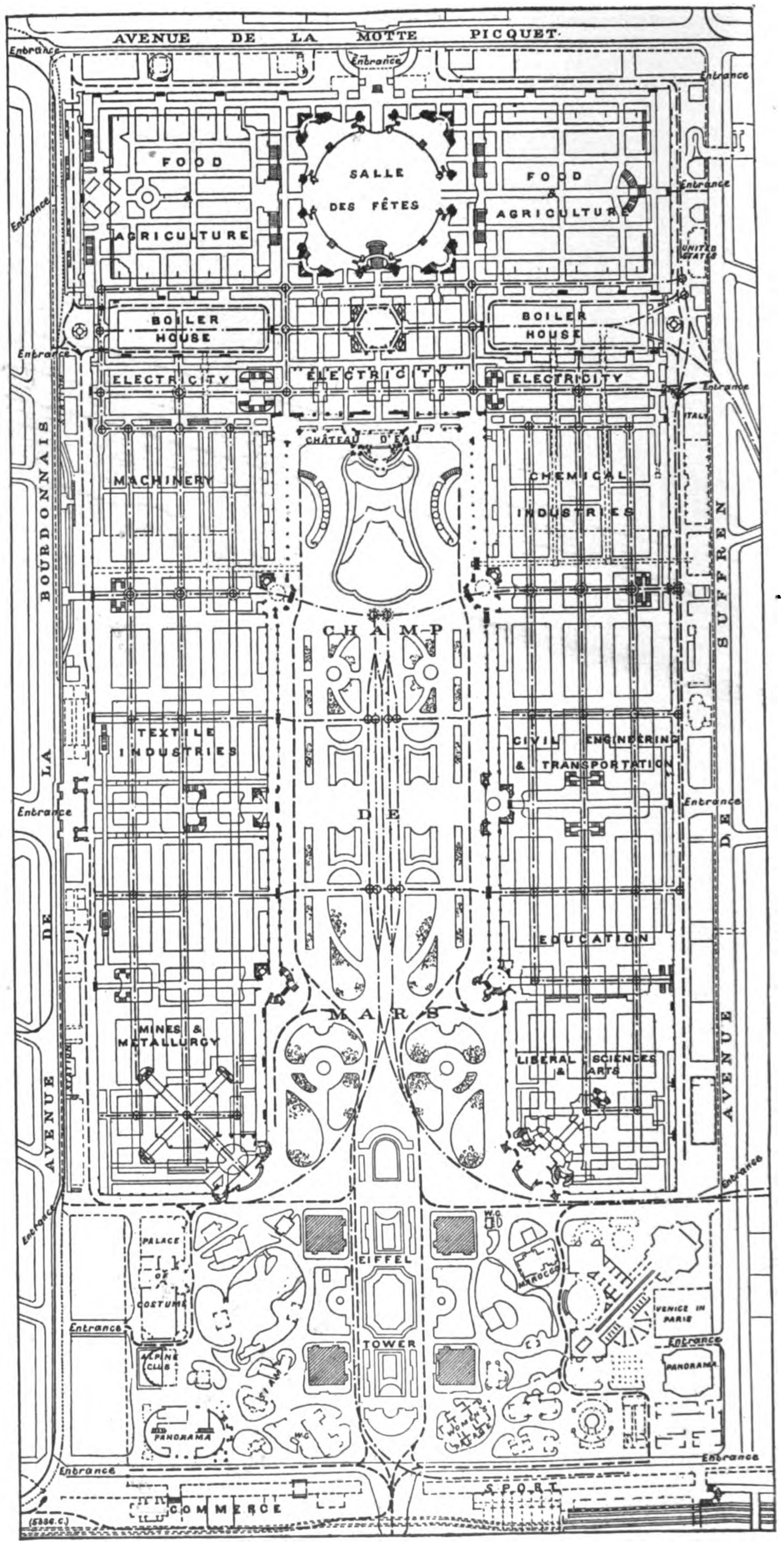

AVENUE DE LA MOTTE PICQUET
Entrance
FOOD AGRICULTURE
SALLE DES FÊTES
FOOD AGRICULTURE
UNITED STATES
BOILER HOUSE
BOILER HOUSE
ELECTRICITY
ELECTRICITY
ELECTRICITY
ITALY
CHATEAU D'EAU
MACHINERY
CHEMICAL INDUSTRIES
AVENUE DE LA BOURDONNAIS
AVENUE DE SUFFREN
CHAMP DE MARS
TEXTILE INDUSTRIES
CIVIL ENGINEERING & TRANSPORTATION
EDUCATION
MINES & METALLURGY
LIBERAL SCIENCES & ARTS
PALACE OF COSTUME
EIFFEL TOWER
MAROCCO
VENICE IN PARIS
ALPINE CLUB
PANORAMA
PANORAMA
COMMERCE
SPORT
(5386 C.)

FIG. 7.—PLAN OF THE CHAMP DE MARS.

The various requirements for the tunnels are to provide for the distribution of water at low pressure for purposes of condensation, this water being taken from the lower basin of the Chateau d'Eau; for returning to the river the warm water from the condensers; for carrying steam to the engines in the two power houses and to various smaller machines in the vicinity and for distribution of feed water for the boilers. The largest form of tunnel is intended to carry the large water pipes, 31 ins. in diameter, which draw the condensing water from the lower basin and return it, after use, to the Seine. This size is also used for the main artery uniting the stations of Bourdonnais and Suffren, and passing between the boiler and engine rooms. The water pipes are laid on masonry supports in the lower portion of the tunnels, and steam pipes are carried on a second and higher step of the wall nearer the side of the tunnel, supported on rollers in order to provide for expansion.

Some of the large engines being likely to require more steam than a single 10-in. pipe could supply, additional supports for pipes of the same size are provided along the roof, which are also available for the suspension of feed-water pipes.

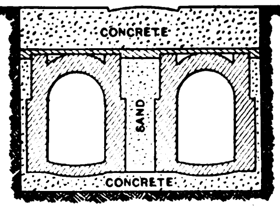

CONCRETE
SAND
CONCRETE

FIG. 8.—FIRST SECTION OF BOILER FLUES.

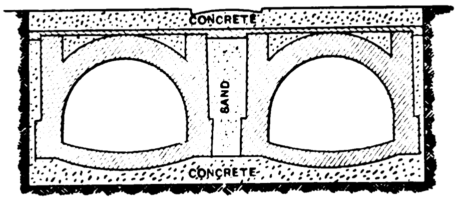

CONCRETE
SAND
CONCRETE

FIG. 9.—SECOND SECTION OF BOILER FLUES.

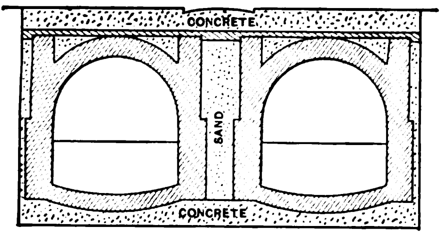

CONCRETE
SAND
CONCRETE

FIG. 10.- THIRD SECTION OF BOILER FLUES.

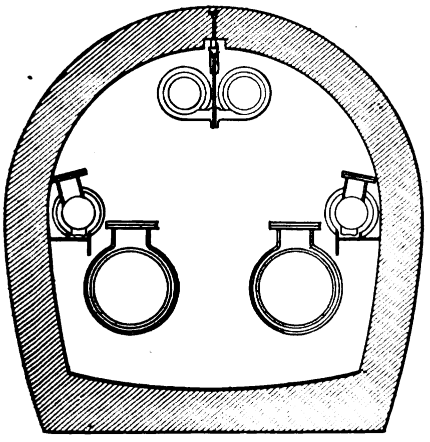


FIG. 11.—SECTION OF A PIPE TUNNEL; TYPE 1.

The second size of tunnel is used for the double branchings from the main above-mentioned, and is built beneath the floor of the Chemical Industries and Mechanics sections, constituting the greater part of the subterranean passageway. The condenser water supply is here carried by 24-in. pipes, and in the sub-branches of these buildings by 20-in. pipes, and in one case 16-in. All steam pipes remain 10 ins. in diameter. The smallest size of tunnel, No. 3, allows the installation of 20-in. pipes for the condenser service, as well as the steam pipes on the upper level. This size is used only to serve machines in the central halls between the two boiler rooms. At those points where the tunnels cross each other, square chambers are built, 15 ft. 9 ins. long on each side, and extending up to the ground level from the tunnel floor.

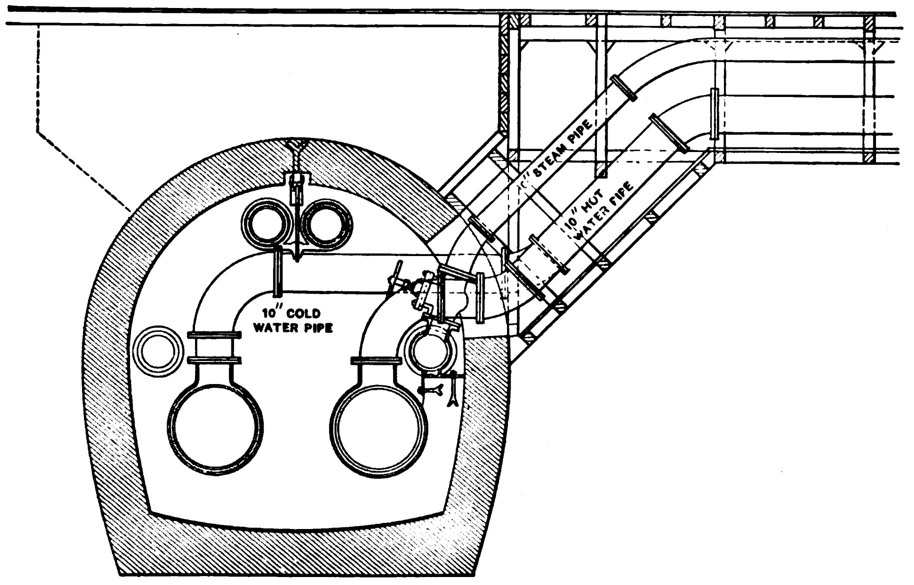

STEAM PIPE
10" HOT WATER PIPE
10" COLD WATER PIPE

FIG. 12 —SHOWING METHOD OF RUNNING CONNECTIONS FROM ENGINES TO TUNNEL MAINS.

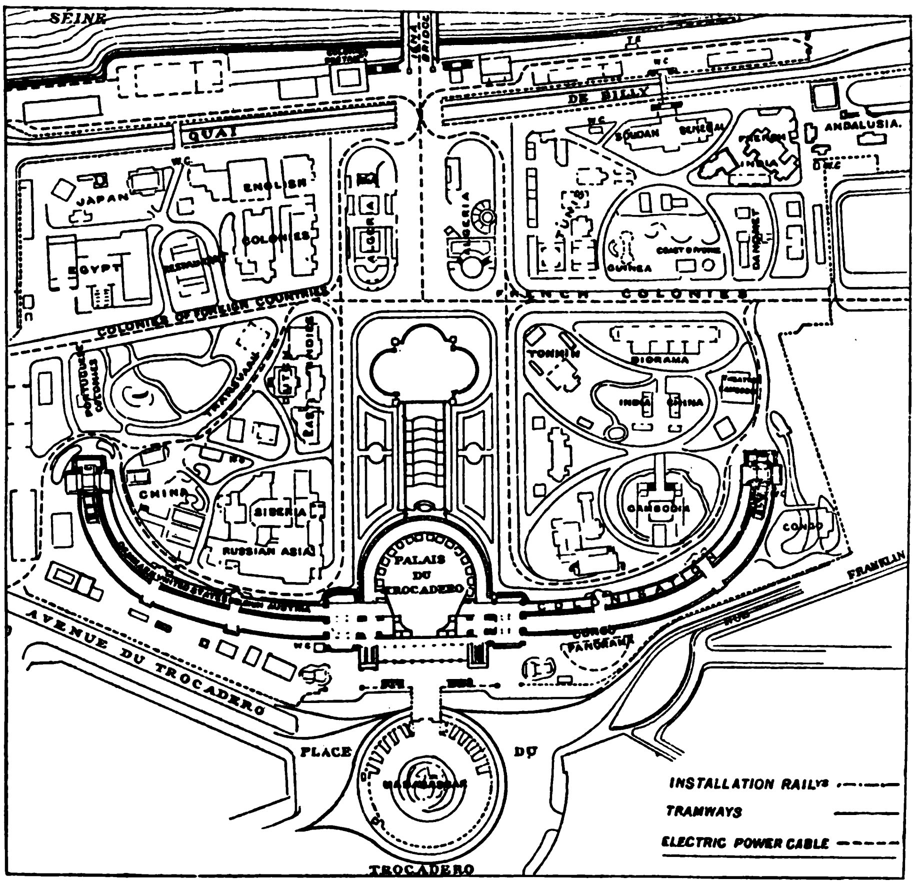

SEINE
IENA BRIDGE
QUAI
DE BILLY
JAPAN
ENGLISH
COLONIES
EGYPT
ALGERIA
SOUDAN
SENEGAL
ANDALUSIA
INDIA
DAHOMEY
GUINEA
FRENCH COLONIES
COLONIES OF FOREIGN COUNTRIES
TONKIN
DIORAMA
INDO CHINA
CHINA
SIBERIA
RUSSIAN ASIA
CAMBODIA
CONGO
PALAIS DU TROCADERO
PANORAMA
AVENUE DU TROCADERO
FRANKLIN
PLACE DU TROCADERO
INSTALLATION RAILS
TRAMWAYS
ELECTRIC POWER CABLE

FIG. 13.—PLAN OF THE TROCADERO.

The steam piping is divided into sections of about 100 ft., connected by expansion joints. These consist of a bronze sleeve bolted in the usual manner to the steam pipe flange and sliding within a stuffing-box with bronze wearing parts fitted to a cast-iron cylinder, which in its turn is fitted to the next length of pipe. The joints between pipe lengths are made by forcing a short double-tapered cylindrical ring into the ends of the pipes and drawing the joint up close by means of bolts through the flanges. This method is also used in securing the tubes of the De Naeyer boilers, and it is said to give steam-tight joints under high pressure, dispensing with packing, and to necessitate fewer bolts.

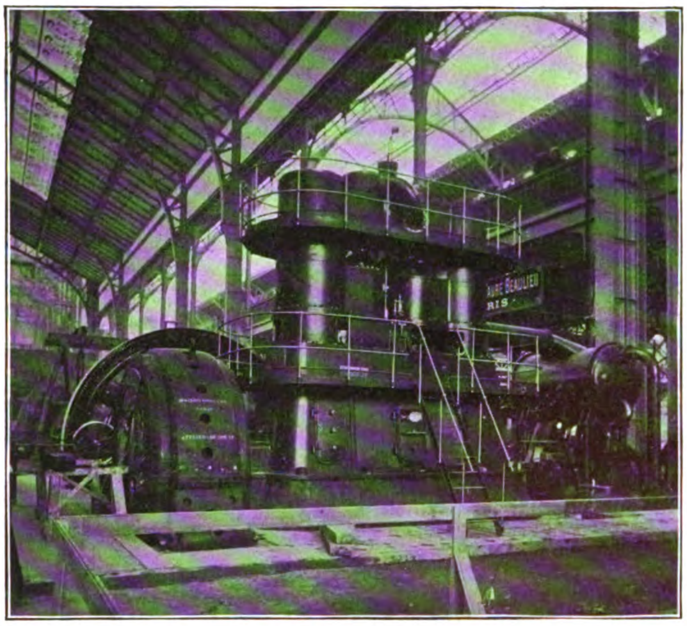


FIG. 14—DELAUNAY-BELLEVILLE ENGINE AND BREGUET GENERATOR.

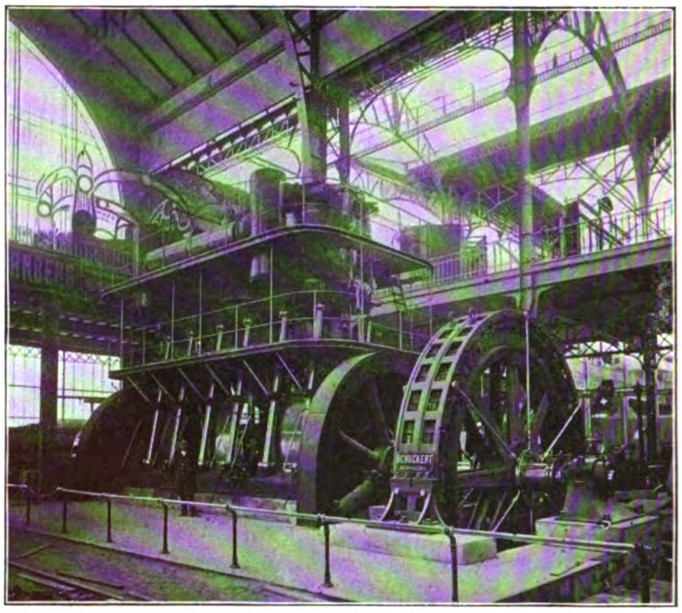


FIG. 15.—SCHUCKERT GENERATOR AND NUREMBERG ENGINE.

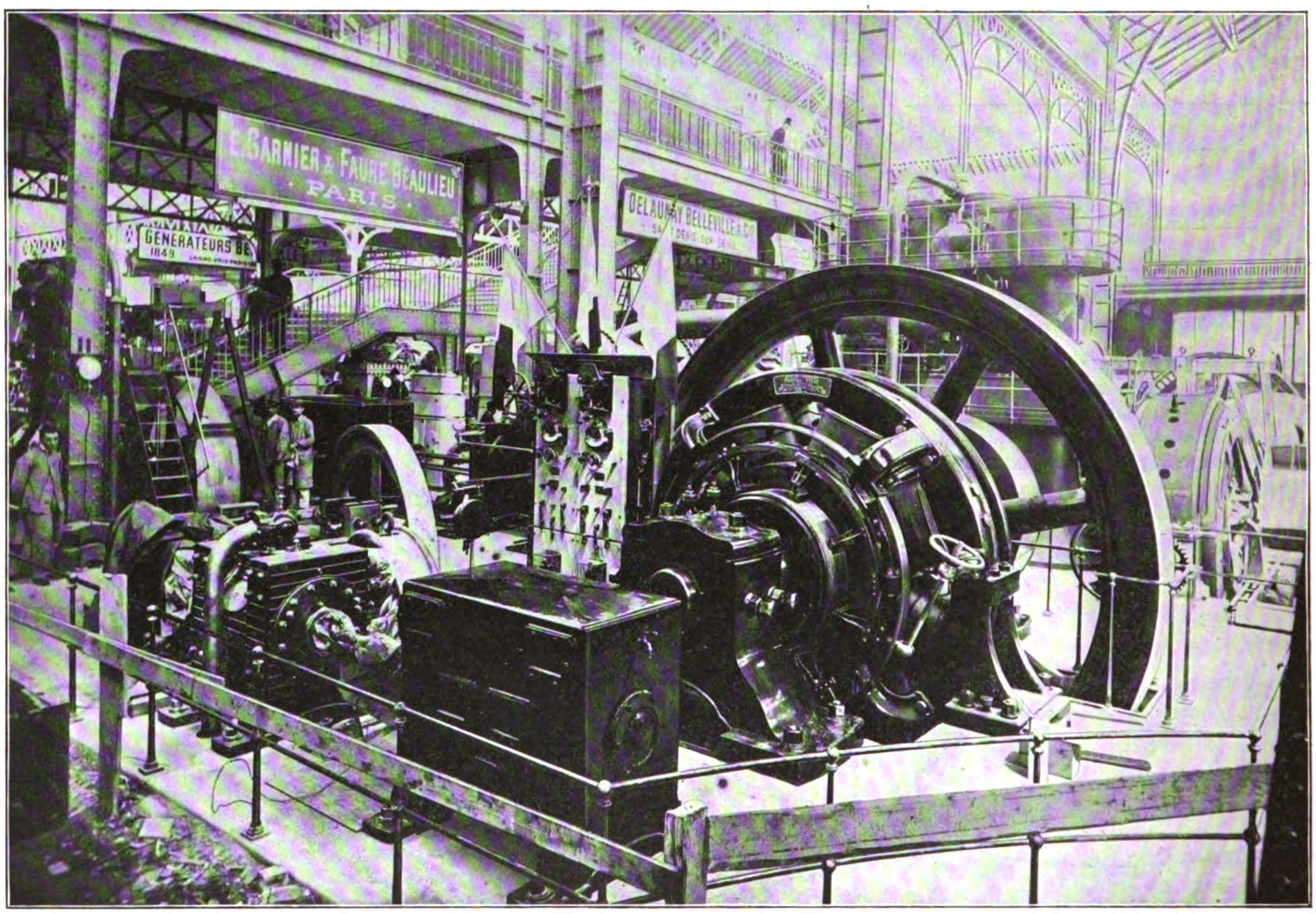


FIG. 16.—POSTEL-VINAY DIRECT-CONNECTED 440-VOLT GENERATOR IN FRENCH SECTION.

Condensation in the steam pipes is drawn off through automatic separators or drains, which allow the water to pass through a valve which is closed when the hotter steam begins to escape. Special siphon chambers force this water into drain pipes suspended from the roof. These separators are located in the square chambers already mentioned, and in some cases the expansion joints are fitted with drainage outlets. In the boiler rooms, reservoirs are placed in each ventilating shaft to collect the condensation, which flows in at the top after passing through the separators, and out at the bottom into the general drainage system. An overflow is provided near the inlet, whence the water, in case of stoppage of the lower outlet, falls to the tunnel floor. The tunnels are, however, graded, so that in the event of a serious leak in a pipe the water would run through into the sewers and no interruption in power service would result.

The water in the Chateau d'Eau, at the end of the Champ de Mars, is pumped up from the Seine, at the other end of the Champ de Mars, by Worthington pumping machinery, and is delivered to the fountains through two 30-in. pipes. The Worthington Company put up a special building to receive its pumps, and not content with designing these, the company's engineer, Mr. Marechal, also designed the building. The construction is remarkable in its lightness and strength, for, although a steel structure, there is not a single piece in its design which cannot be handled by one man, and the total weight of the steel is only about 60 or 70 tons. The pumps are arranged in two groups of two machines each. The first requirement of the Exposition authorities was the delivery of 20,000,000 gallons of water per day; but this was subsequently changed to 30,000,000 gallons. However, there is a capacity of more than 40,000,000 gallons in the present plant. The pumps are required to operate from 9:30 in the morning to 12, and from 1:30 to 5:30 in the afternoon; also from dusk or the time of illumination to the closing hour. The engines in the power house are supposed to be in readiness to run at 10 o'clock a. m.

The engines which drive the dynamos furnishing power and light for the Exposition are placed in two groups, close to the boiler rooms. At the extreme end of the extreme end of the Suffren station is the German section, containing four large units, all ready to move, but still lacking steam and water. The terraces of the Chateau d'Eau have been responsible in great measure for the delay. At the present writing the British engines are still missing. Some of the French manufacturers are ready, but in general they are much behindhand, and the greater proportion are still building.

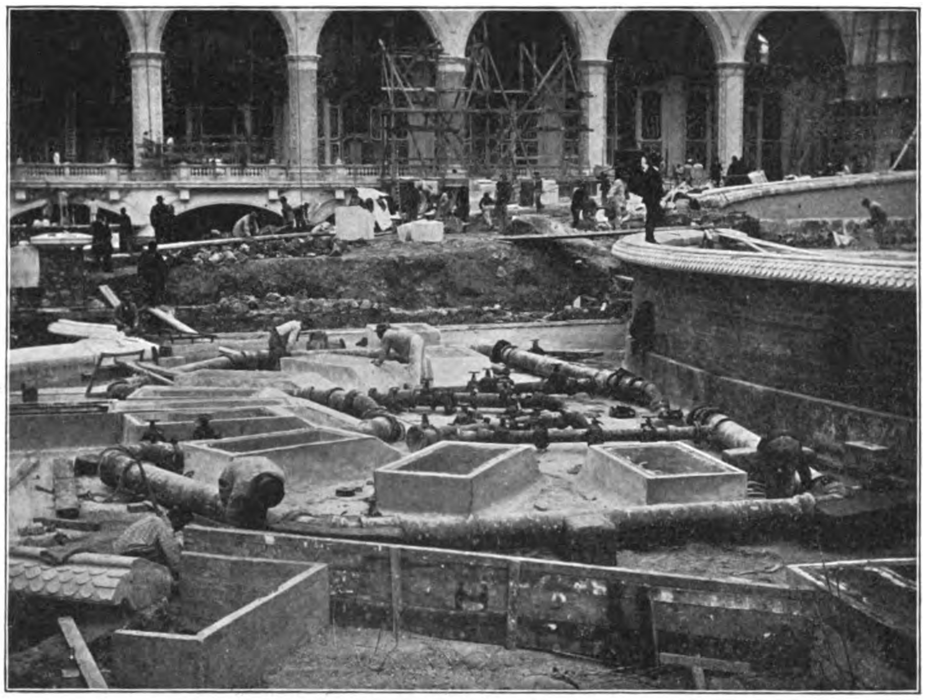


FIG. 18.—BED OF ELECTRIC FOUNTAIN, SHOWING PROJECTOR WINDOWS.

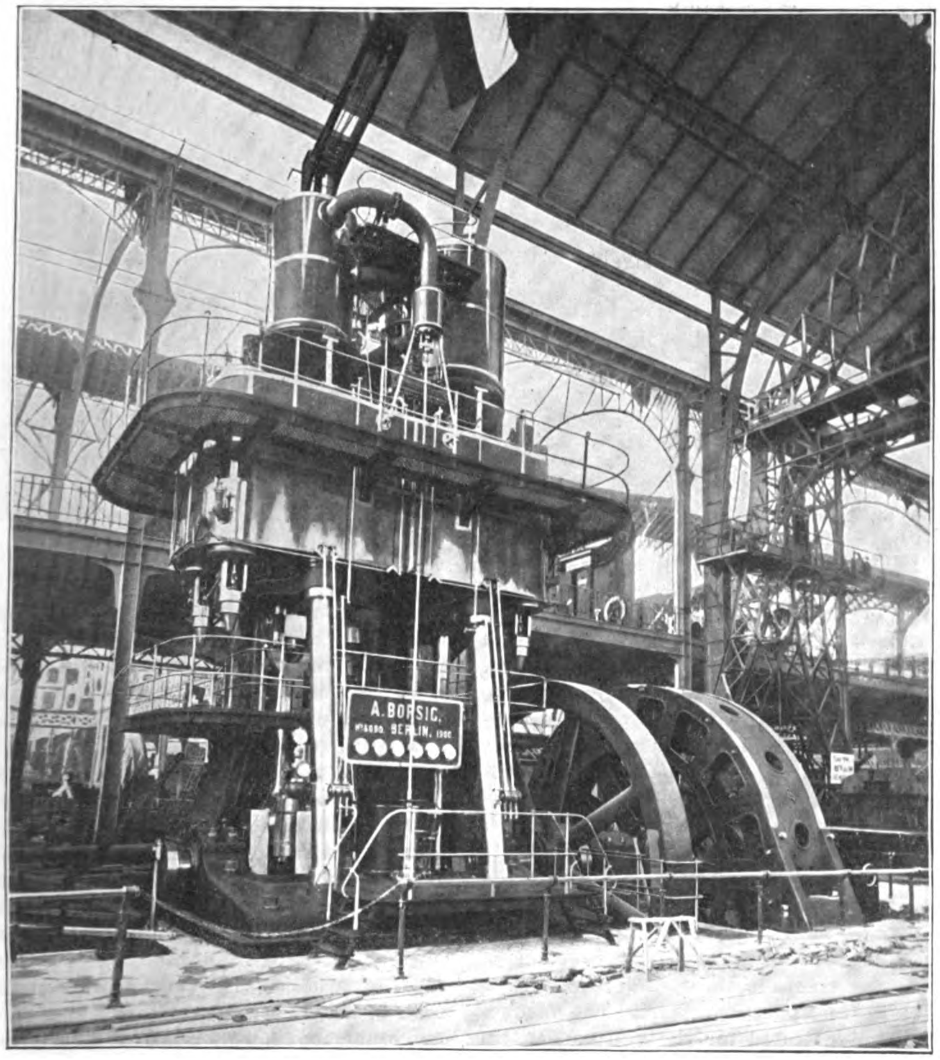


FIG. 17.—BORSIG ENGINE AND SIEMENS & HALSKE GENERATOR.

There are 18 engines in the Bourdonnais station and in the Suffren station there are 19. The large German machines raise the average horse-power per unit to a much higher figure than the French station can show; but the foreign engines are in general of higher output individually. Several French engine builders make use of the single cylinder construction, so that they cannot use steam at the standard pressure of 140 pounds, and have to use reducing valves. On the other hand, the German builders use triple expansion, and intend their engines for use with steam at 200 pounds to the square inch.

The first of the group of German machines is a vertical engine by Borsig of Berlin, built to give 3000 horse-power at 85 r.p.m., with steam at 200 pounds per square inch. Running, however, at 83.5 r.p.m., with 140 pounds steam pressure, the output is given as 2500 horse-power. The high-pressure cylinder has a diameter of 30 ins., the intermediate 46½ ins., and the two low-pressure cylinders each 52¾ ins. The stroke is 47¼ ins. Two cranks are used, placed at 180 degs. At one end of the shaft is the dynamo, built by Siemens & Halske of Berlin, giving three-phase currents at 2200 volts. The armature, which is stationary, surrounds the revolving field, and is carried on a circular frame so arranged that it may be turned on its roller supports, should trouble develop in an otherwise rather inaccessible part of the winding.

The adjustment of the air gap is obtained by slight changes in the positions of the supports below, and the frame may be firmly locked by means of bolts passing through the cradles at the sides. The exciter is an 8-pole machine, giving 214 amperes at 210 volts, at 83.5 r.p.m. As a higher-speed machine, running at 340 r.p.m., the output reaches 200 kilowatts.

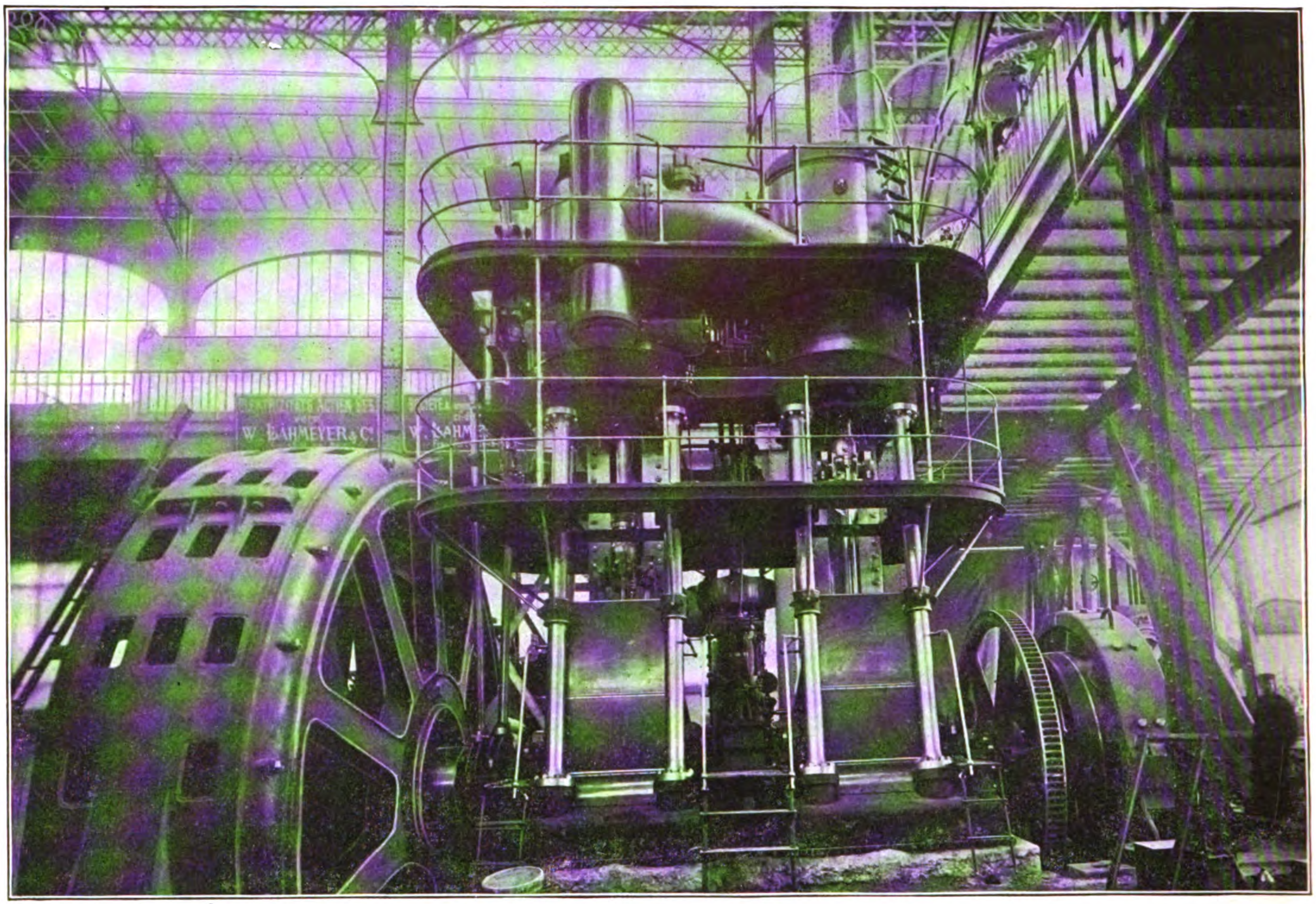


FIG. 19. AUGSBURG NUREMBERG ENGINE DRIVING LAHMEYER ALTERNATOR AND EXCITER.

The second German engine and generator set is built by the Nuremberg Engine Company, and Schuckert & Co. This is also a vertical engine of 2000 horse-power, triple expansion, having at one end of the shaft a direct-current dynamo giving 800 kilowatts at 500 volts, and at the other end a 3-phase 850-kw. alternator furnishing current at 5000 volts. The stroke of the engine is about 43 ins., and the cylinders are 30½ ins., 48¾ ins., and 71 ins. in diameter, only three cylinders being used. The speed is 83 r.p.m. This engine is intended for the central station at Essen-on-the-Ruhe, to furnish light and power, The weight, complete, is 530,000 pounds.

Another vertical engine, compound, of 1400 horse-power, is shown by the Nuremberg and Augsburg Consolidated Engine Company, direct coupled on one side to a 790-kw. three-phase generator giving 5000 volts, and on the other side to a direct-current 350-kw. 500-volt machine, built by the Lahmeyer Electric Company. The speed is 94 r.p.m., and the weight 265,000 pounds. In the Belgian section this engine builder has a triple-expansion vertical engine of 500 horse-power coupled to a single-phase 2000-volt alternator by the Electric & Hydraulic Society of Charleroi, but this exhibit will not be shown in operation.

The fourth engine of this group is a horizontal four cylinder triple expansion 1900 horse-power engine, by the Augsburg Engine Company, who make a specialty of this type, while the Nuremberg Engine Company builds vertical engines. The alternator is furnished by the Helios Electric Company, and supplies single-phase or three-phase currents. The special features to be observed in this engine, apart from the fact that it is the only horizontal one in the German section, are the centralized systems of control, both of the mechanical and electrical performance. Within the rectagle enclosed by the cylinders are the main steam valve, the governor, the steam-jacket valves, the main switch handle, the exciter field and generator field regulator levers, and instruments showing the exciter and generator voltages and the current output on the three lines; also gauges indicating the steam pressure in the high-pressure, intermediate, and low-pressure cylinders, the latter having a negative scale extension of a few points to show when expansion is below atmospheric pressure. The vacuum is also indicated for the two condensers below, one on either side of the engine.

All steam pipes and connections are below the floor level; the steam inlet to the high-pressure cylinder is opened by revolving a hand wheel which operate the main valve, this being always wide open during the running of the engine. If, however, it should become necessary to quickly shut off steam, this can be accomplished in a moment by pulling over a lever, which breaks the direct line of the rods actuating the high-pressure valve and shuts off steam from the cylinder. Regulation of speed is obtained by a ball governor which may be accurately adjusted or changed at any time by sliding a weight along an arm by means of a screw. The air pumps for the condensers are operated by connecting rods attached to the crossheads. In order to relieve back pressure a small three-phase motor is installed below, direct-connected to a centrifugal pump, raising the water three meters to a higher level for running off.

The exciter is not mounted on the engine shaft as is the case with the other units, but is installed a little distance away on its own foundation and is driven by a 60-h.p. marine-type condensing engine. This is larger than is needed for exciting the generator, but some of the power is used to light the passage-ways which extend beneath the engine. The main switch is mounted down there, on a finely finished marble board. There are three double-contact knife blades which are brought successively into contact with the clips, by turning a horizontal wheel on the engine room floor above. Immediately underneath the wheel are the two levers, to right and left, controlling the resistances to be inserted in the field circuits, these resistance coils being close to the main switch-board and cut in or out directly by the movement of the levers.

The only engine in the foreign section, outside of the German machines, which is ready, is the horizontal engine of 1000 horse-power built by Carels Bros., of Ghent, driving a 560-kw. three-phase 3000-volt generator built by the Kolben Electric Company. Among the French engine builders, Delaunay-Belleville & Co. are ready to run their 1250-h.-p. vertical triple-expansion engine. A compound wound Breguet alternator is direct-connected, giving an output of 736 kilowatts at 250 r.p.m., the e.m.f. being 2200 volts. The 440-horse-power engine of Garnier & Faure, Beaulieu, has been ready for some weeks

It is interesting to note that the Postel-Vinay Company, who built the generator which is direct-coupled to this engine, manufacture for the French Thomson-Houston Company, and the machine is actually a standard 8-pole 350-kw. traction generator, running at 90 r.p.m. The air-gap is larger than normal, and the e.m.f. is reduced to 440 volts. On the other side of the engine room the French Thomson-Houston Company is putting in a large alternator driven by a vertical engine of the type and design of the E. P. Allis Company. This machine is a long way from being ready, but promises to be one of the finest generating sets in the station.

The appended tables give a summary of the generating equipment.

A striking peculiarity of many of the French engines is the use of a single cylinder, as, for instance, in the case of a horizontal engine by Weyher & Richemond, in which one cylinder furnishes the whole output of 1000 h.p. It would naturally seem that the rotation could not be very

Equipment in the Bourdonnais Station

	Engine h. p.	Dyn. kw.	Nature of Current.	Voltage and Frequency.
Alsacian Society (Societe Alsacienne)	1200	675	Con.	500
Crepelle & Garand—Decauville Soc	1200	675	"	250
Laval Society, two equipments each	350	200	"	250
Fives-Lille Company	1200	675	3 ph.	2200; 50
Piguet & Co.—A. Grammont	600	335	"	2200; 50
Garnier & Faure—Beaulieu—Postel—Vinay	440	225	Con.	440
" " " " "	135	75	"	500
Dujarden & Co.—Electric Lighting Soc	800	440	3 ph.	3000; 50
Bietrix, Leflaive, Nicolet & Co.—Elec. Ltg. Soc	350	190	Con.	250
P. & A. Farcot	850	480	2 ph.	2200; 42
Weyher & Richemond—Dayde & Pille	1000	560	Con.	250
" " —Gen. Electric Soc of Nancy	500	280	3 ph.	3000; 50
" " —Electric & Hydraulic Society	1000	560	"	2200; 50
Delunay—Belleville & Co.—Breguet	1250	736	"	2200; 50
Cail Establishment—French Thomson-Houston Co.	1250	600	"	5500; 25
Dujardin & Co.—Schneider & Co	1500	840	"	3000; 50
Hauts-Fourneaux de Maubeuge	5 0	280	Con.	250

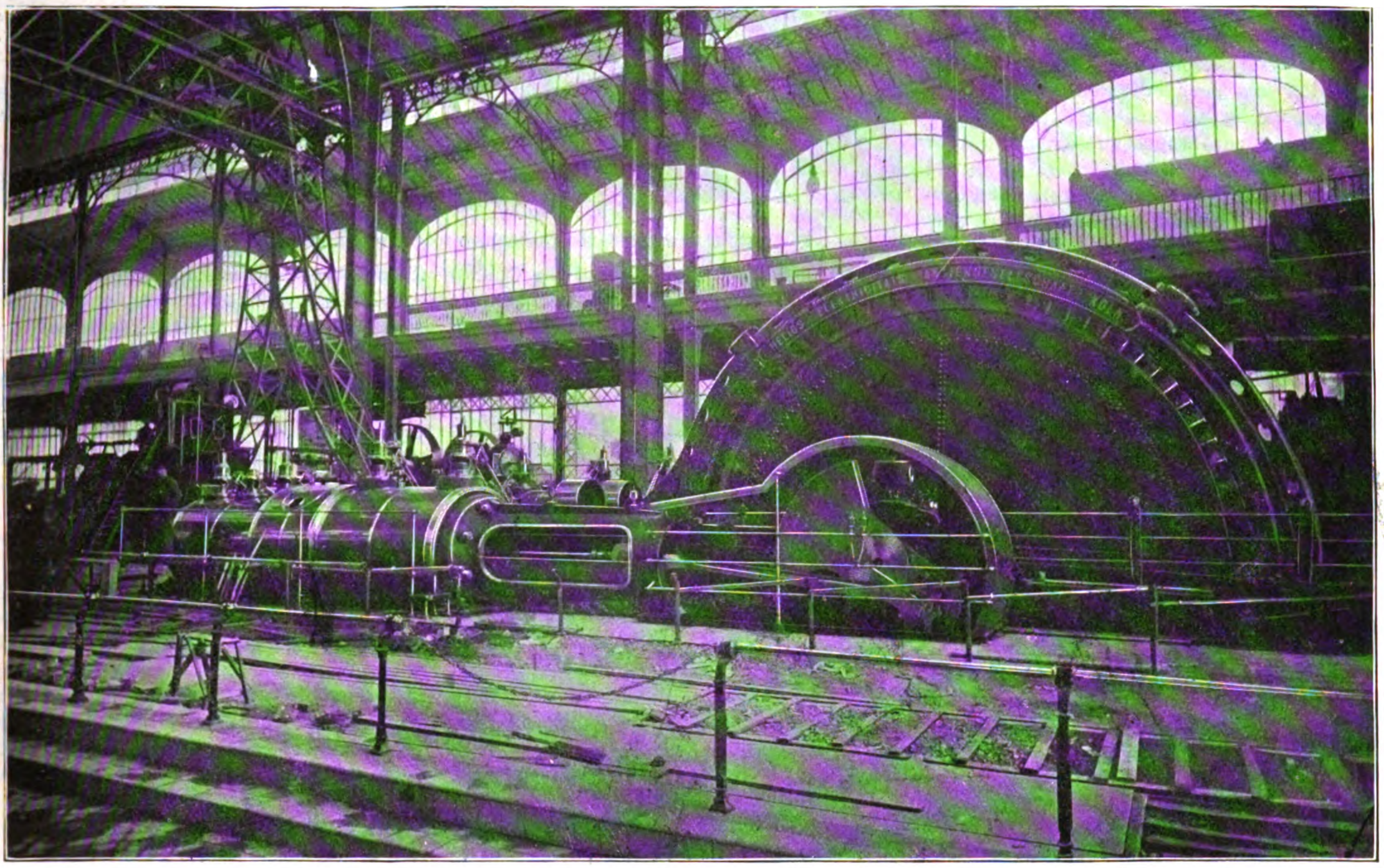


FIG. 20. AUGSBURG ENGINE DRIVING A HELIOS ALTERNATING CURRENT GENERATOR.

Equipment in the Suffren Station.

		Engine h. p.	Dyn. kw.	Nature of Current.	Voltage and Frequency.
Grt Britain.	Robey & Co	500	280	Con.	250
	Willans & Robinson—Siemens Bros	2100	1340	"	500
	Galloways, Ltd.—Mather & Platt	500	280	"	250
Holland	Stork Bros. & Co.—Electrotechnical Industry (Smit)	550	300	"	500
Germany	Augsburg Engine Co.—Helios Electric Co	1900	1060	Alt.	22 0 ;50
	Nuremberg Engine Co.—Schuckert & Co	2000	800 850	Con. 3 ph.	500 5000; 50
	A. Borsig—Siemens & Halske	2500	1500	"	2200; 50
	Augsburg & Nuremberg Con. Eng. Co.—Lahmeyer Electric Co	1400	350 790	Con. "	250 5000; 50
Belgium.	Carels Bros.—Kolben Electric Co	1000	560	3 ph	3000; 50
	Bollinckx—Electric & Hydraulic Soc	1100	620	"	2200; 42
	Van den Kerchove—Industrial Electric Co. (Pieper)	1000	560	"	2200; 50
Austria	Ringhoffer—Siemens & Halske	1600	900	Con.	500
	Erste Brunner Engine Co.—Ganz & Co.	910	610	3 ph.	2200; 42
Hungary	Ladislas Lang—Ganz & Co	1200	675	"	2200; 50
Switzerland.	Sulzer Bros.—Oerlikon Works	400	230	Alt.	2200; 50
	Escher Wyss & Co.—Oerlikon Works	900	500	3 ph.	2200; 50
	Emile Mertz—Alioth Elec. Soc	460	200	Con.	500
	Franco Tosi—Schuckert & Co	1200	700	"	500
	Franco Tosi—Bacini Soc	600	350	"	500

even but would show pulsations plainly.

There still remains very much to be done before the two power stations will be in full running order. Until the flooring is all down and the engine rooms quite clean, the German exhibitors are not anxious to run their engines, as the air is laden with dust and sand.

The main switchboard is still under construction, being located on the ground level of the Electricity Building, behind the Chateau d'Eau. From this point the various sections of the Exposition grounds will be supplied with currents.

The distribution of light and power is as follows: Low-tension current is used in the buildings of the Champ de Mars, for both light and power, for the interior of the Invalides Palace a two-wire 500-volt system is installed for power only. In the case of alternating-current supply, the machines have been so connected to the switchboard that all those possessing the same characteristics of voltage and frequency are grouped together. The Exposition has been divided into sections corresponding to those groups, thereby assuring a continuous supply of light or power even though some machine should break down. Single-phase alternating current is distributed through the section surrounding the Champ de Mars on the outer facade, the primary being 2000 volts and the secondary 110 volts; the frequency is 50 periods per second. Three-phase current is available during running hours of the plant in the gardens of the Champ de Mars, Trocadero and Quai Debilly, near the Trocadero, at 2000—110 volts and a frequency of 50. During lighting hours three-phase current is available on the Quai d'Orsay, below the Alma Bridge, at the same tension, but the frequency is 42 periods per second. Above the Alma Bridge, on the Quai d'Orsay, the primary is 4800 volts and the secondary 110 volts, and the frequency 50 periods per second. On the western side of the Invalides (rue Fabert), the primary is 4800, or 2000 volts, secondary 110 volts, frequency 50. On the eastern side (rue Constantine) the primary is 2000 volts, secondary 110 volts, frequency 50.

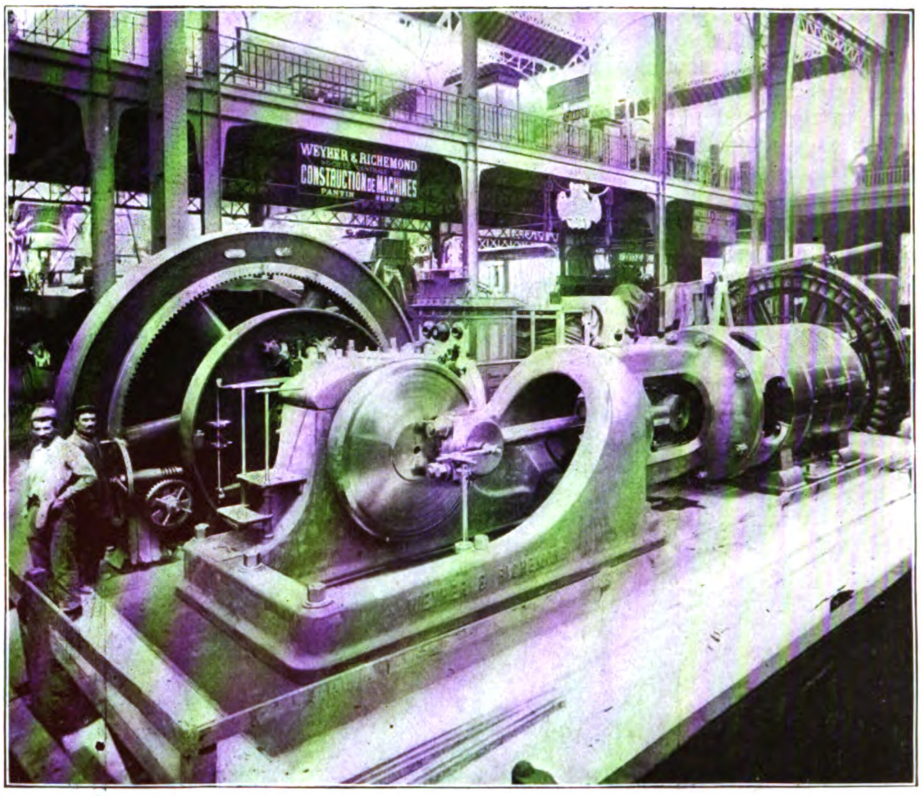


FIG. 21.—WEYHER & RICHEMOND 1000-H.P. SINGLE-CYLINDER ENGINE.

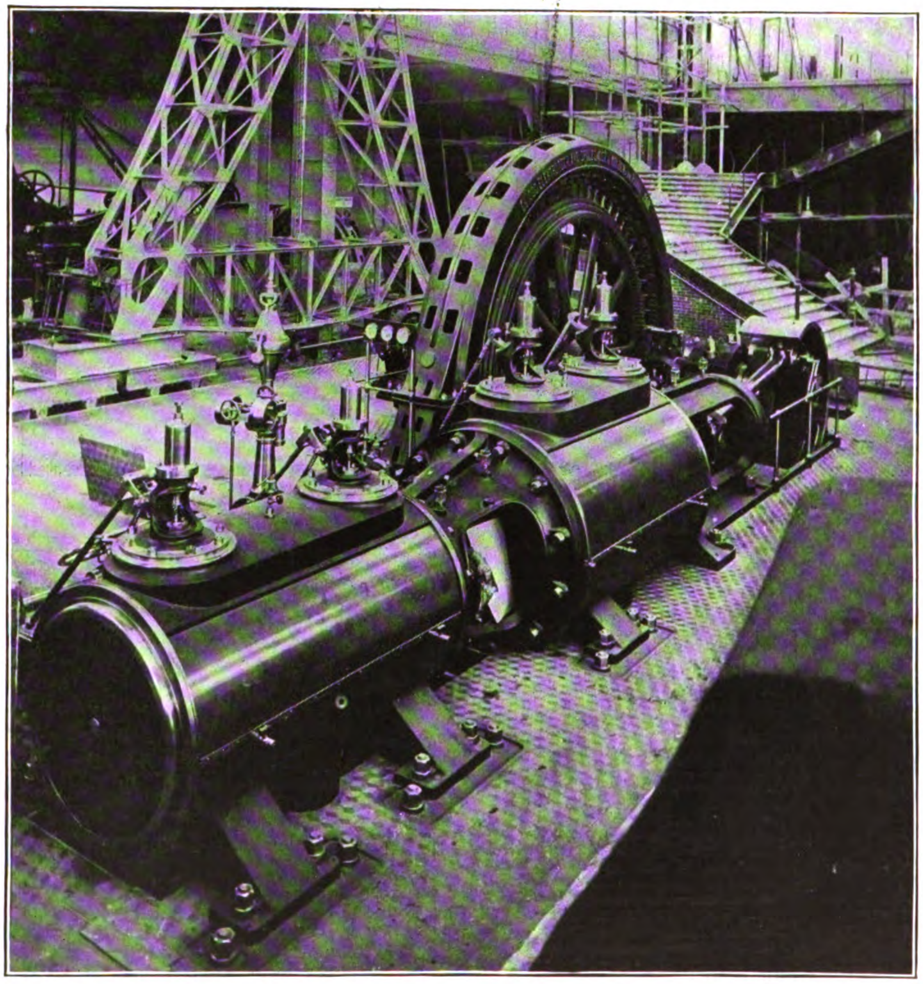


FIG. 22.—CARELS ENGINE DRIVING KOLBEN ALTERNATOR.

One of the features of the Exposition that will undoubtedly prove immensely interesting is a miniature firmament. A sphere about 150 ft. in diameter, known as the Globe Celeste, is mounted upon four ornamental masonry pillars, the top of the foundation being surrounded by a terrace which has a height of about 130 ft. from the ground. On the outside of the sphere the constellations are represented in their appropriate order, with the mythological figures appropriate to each, and the whole is electrically illuminated. The interior is reached by a stairway or electric elevators, from which one enters the center of a second sphere about 114 ft. in diameter.

In an artificial firmament are represented the sun, planets, nebulae, etc., by means of electric bulbs of greater or less intensity and of various colors. In the center an earth about 26 ft. in diameter turns on its axis. By this rotation the sun and planets take the proper movement; the moon revolves around the earth and changes its phases, and eclipses are also represented. Although these movements are necessarily relatively rapid, they are proportionately exact. A great organ has been installed in the sphere for recitals.

STEAM ENGINEERING IN CENTRAL STATIONS.

THE SELECTION OF AN ENGINE FOR A POWER STATION.

BY R. C. CARPENTER.

The selection of the best type of engine for a given power station is a matter which requires some consideration and even under best conditions may be a difficult problem. The great variety of engines which are offered for sale and the advantages claimed for each class tend to confuse rather than enlighten a novice who for the first time considers the subject.

Considering condensing engines: The effect of removing the back pressure from an engine is to increase the amount of work performed by a given volume of steam, and consequently to increase its economy. If the steam pressure is low, the effect of a condenser is more marked than if the pressure is high. If the atmospheric pressure were all removed the vacuum would be perfect and would be expressed as 29.92 ins. of mercury, or practically 30 ins. at the sea level, being in every case for that condition equal to the barometer reading. A vacuum of 25 ins. is frequently obtained in the operation of a plant, which is equivalent to a back pressure of 5 ins. With the steam pressures ordinarily used a vacuum of 25 ins. would reduce the coal burned or the steam used by about 33 per cent. under usual conditions of practice. From a commercial standpoint one could then afford to pay for the condensing engine and the water required for condensation such an amount as the saving would pay a good rate of interest on.

As an illustration, suppose that a simple non-condensing engine of 100 h.p. working 16 hours a day for 300 days in the year requires 6 lbs. of coal per horsepower per hour and that by the installation of a condenser the coal consumption can be cut down to 4 lbs. of coal per hour. We should find that the non-condensing engine would use 1440 tons of coal per year and the condensing engine would use 960 tons per year, the saving by the improvement being 480 tons of coal per year. The cost of the coal would have its influence on the amount that might be paid for the improvement. If the coal was worth $2 per ton the saving would be evidently $960 per year, if $3 per ton the saving would be $1440 per year. This amount must in each case pay interest on the extra investment and also the cost of the condensing water.

It is thus seen that the cost of operating a steam plant is very much less when engines are run condensing than when run non-condensing. To operate engines condensing there is required either an abundant supply of cold water or some means of cooling the condensing water so that it can be used over and over. The amount of water required for condensing purposes depends upon the vacuum produced and the temperature of the condensing water. In general the condensing water required will be 15 to 20 times the feed water needed for the boiler and converted into steam. By changing from non-condensing to condensing engines the feed water is reduced, as before mentioned, approximately one-third, consequently the total amount of feed water and condensing water for the condensing plant would be approximately 12 to 15 times the amount of feed water required for the non-condensing plant.

Engines are made simple, compound, triple-expansion and quadruple-expansion. The increased economy due to the use of additional cylinders is not, as popularly supposed, because the steam is used more than once, but it is due to the saving which comes from reducing cylinder condensation by preventing an excessive variation in temperature in any one of the cylinders. The multiple-cylinder engine also presents practical methods of increasing the number of expansions of steam, which is in itself an element of economy. The gain in the use of multiple cylinders as compared with a single-cylinder engine is a greater percentage when two cylinders are used than afterward. The amount of gain by increasing the number of cylinders as compared with the simple cylinder would seem to run approximately as the fractions ¼, 1/7 and 1/10; that is, the saving obtained by changing from a simple to a compound engine is approximately one-fourth of the coal burned by the simple engine; the saving from compound to triple is approximately one-seventh of that used by the compound engine, while the saving from the use of a quadruple expansion would seem to be about one-tenth of that used by the triple expansion. All these results are of course much modified by the pressure of steam and by the vacuum. The following table, however, gives approximately the weight of steam used by multiple-cylinder engines, with different number of cylinders:

Pounds of Steam per I.H.P. Per Hour.

No. of cylinders	I.	II.	III.	IV.
Non-condensing	32	24	20.9	18.3
Condensing	24	16	13.5	12.2

The results in the above table are not in any case record figures, but are those which should be expected in tests from engines in fair condition, and operating with a steady load. They are, however, higher than can be realized in practice under conditions where the load varies.

The first cost per horse-power of the engine is greater for the multiple-cylinder engines than for the simple engine and the expense increases with the number of cylinders, but on account of the greater economy of the engine with an increased number of cylinders, less boiler capacity is required per engine horse-power. The saving due to this offsets in a great measure the increase in expense of the more economical engine.

For example, a boiler horse-power under ordinary conditions of steam pressure and temperature of feed water produces 30 lbs. of steam per hour. By considering the figures in the preceding table which gives the weight of steam required for engines of various types it will be noted that the non-condensing simple engine would require one boiler horse-power per engine horse-power, while the compound-condensing engine requires less than 0.6 boiler horse-power per engine horse-power, and the triple-expansion condensing engine requires less than one-half boiler horse-power per engine horse-power. The following table is interesting as showing the approximate cost per horse-power for a simple non-condensing engine with boiler and the corresponding costs of compound and triple-expansion engines, with boilers and condensers.

Table of Approximate Costs per Horse-power.

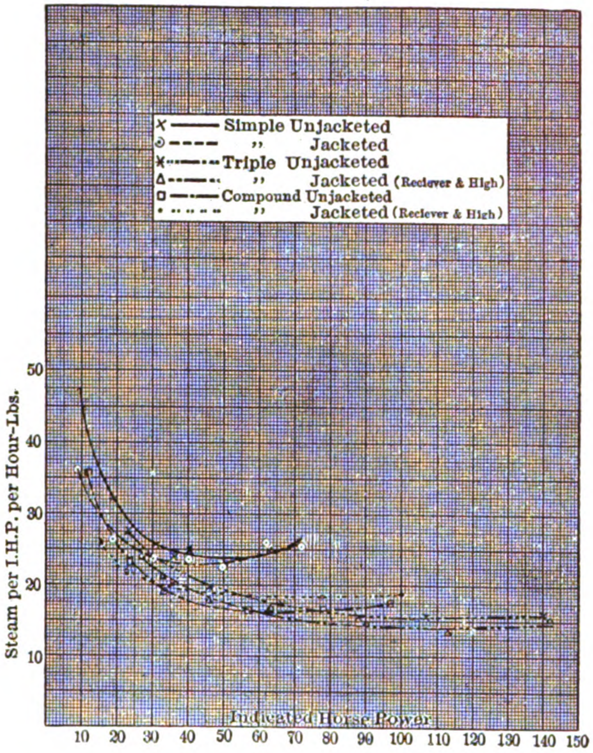
	Simple engine, non-condensing.		Compound engine, condensing.		Triple engine, condensing.	
Engine	$10	$10	$15	$15	$20	$20
Boiler	18	14	10.80	8.40	9	7
Condenser	..	..	4.0	4.0	4	4
	$28	$24	$29.80	$27.40	$33	$31

From this table it is seen that the saving in cost of boiler for the multiple-cylinder engines counterbalances to a great extent the extra price paid for the engines. When the fact is taken into consideration that the simple engine uses under ordinary conditions, when working 16 hours a day for 300 days in the year, 1440 tons of coal per horse-power, the extra cost of the better engines is insignificant as compared with the saving.

So far as the economy of operation is concerned, there is little or no difference whether multi-cylinder engines are tandems or cross-compounds, but for convenience of repairs and accessibility the cross-compound would generally have the advantage over the tandem engine. Tandem engines are, however, now constructed in such a manner that it is possible to inspect the interior of either cylinder without disturbing in any way any of the other parts of the engine, so that when the engine is of moderate size and of a horizontal type there is little choice between the two styles of engines.

Comparing vertical and horizontal engines, the vertical type is rather more expensive to construct on account of the peculiar nature of its frame, but it has the advantage of working with less friction so far as the piston or the guides are concerned and consequently under similar conditions will give a rather higher economy per horse-power actually delivered than the horizontal engine. The vertical engine for the same power requires somewhat less floor space than the horizontal although it takes more head room; moreover, on account of its extra height it is rather more difficult to clean and keep in repair. For engines smaller than 1000 h.p. the advantages of the vertical over the horizontal type of engine are not of marked importance, and for engines of such size the horizontal type is generally preferable. For larger engines the advantages of the vertical engine become more and more prominent and its disadvantages less, so that for heavy loads it should be adopted to the exclusion of the other types.

Engines built for power stations are constructed for greatly varying rates of rotation. It will be found, however, that the average piston speed does not differ so greatly as the rate of rotation in revolutions per minute since it is the usual practice to use longer cylinders and a greater piston travel with engines having a slow rotative speed, than with those having high speeds. The rotative speed is to a certain extent limited by the character of the valve gear as, for instance, with the Corliss valve gear which is hooked to and unhooked from the governing mechanism during each stroke, a fewer number of revolutions is permissible than when the valve-gear is always connected to the governing device, as in the automatic slide-valve engine. Everything else being equal, the higher the speed the better the economy, since there is less loss of heat by radiation and cooling of the cylinder; but it is usually found that a better distribution of steam is secured in engines having a moderate number of revolutions, and this advantage more than counteracts the saving due to higher speeds. The Corliss valve as compared with the plain slide-valve gives a more rapid closing of the steam ports and a more perfect expansion of the steam, and this is also true of many of the improved valve-gears of other types, of which we may mention McIntosh & Seymour, Wheelock and Green. These latter engines are generally given a comparatively slow rotative speed, but despite that fact both experience and experiment demonstrate that they have a higher economy than the slide-valve engine.



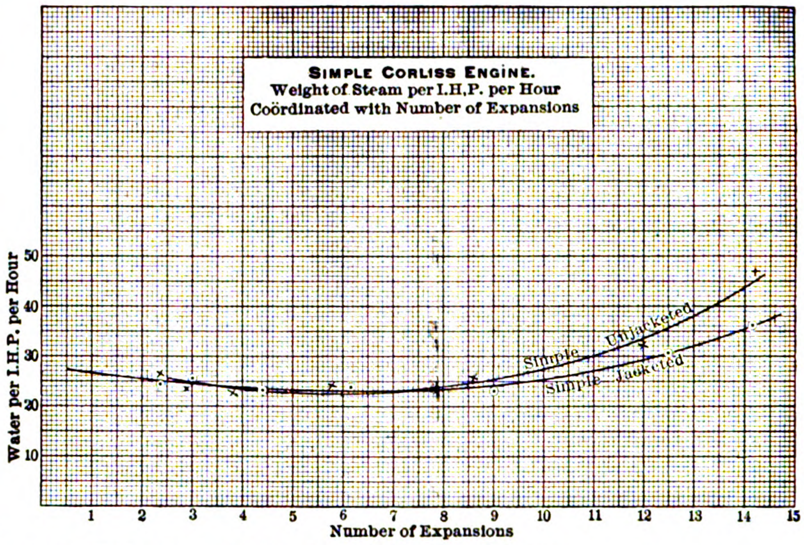


FIG. 1.—PERFORMANCES OF SIMPLE, COMPOUND AND TRIPLE-EXPANSION CORLISS ENGINES.

The effect of change of load on the steam engine has not been discussed in this article. It should be noted, however, that the steam engine, like many other motors, is affected in economy of operation by a change of load to a very great extent. That is, with certain loads much less steam is used per horse-power-hour than with others which are either less or greater. With a very light load the steam is expanded a great many times. This is, of itself, an element of economy, but unfortunately this operation is accompanied by great condensation due to the fact that with light loads the change in temperature of the cylinder becomes excessive, and this more than counterbalances the saving due to using the steam more expansively. The proposition then is true for all classes of engines that the economy or steam used per horse-power-hour diminishes with increase of load up to a certain point, and then slightly increases, and furthermore, that an overload has less detrimental effect on the economy than an underload. This is well shown from the diagrams, Fig. 1, which shows the results of tests with varying loads on Corliss engines of simple, compound and triple-expansion types. It is to be noted that in all cases the engine is very uneconomical with light loads, and further, that it has but one point of high economy. With the simple Corliss engine the best number of expansions when operated condensing seems to be about six, and when running non-condensing, between three and four. With the compound engine running condensing the best results are obtained with about 20 expansions, with the triple-expansion condensing, about 30 expansions.

From a study of the diagrams which show in each case the total horse-power of the engine as horizontal distance or abscissa, and the steam per i.h.p. as vertical distance, it is seen that there is less variation for change in load with the higher grades of engines than with a simple non-condensing, which fact also tends to make the compound or triple-expansion engine more desirable.

As the loads which are available in power houses constructed either for lighting or railway purposes usually vary within quite wide limits it is evidently impossible to secure highest economy from the operation of engines of any type. The varying character of the electric power-house loads have so often been mentioned that little need be said respecting them. The steam engine for railway loads is operated with a continuously varying load unless a storage battery to take the excess of current and supply the deficiency is provided. The engine operating with an incandescent light load is subjected usually to a gradual variation of load, which in the course of a few hours frequently passes from one extreme to the other.

These conditions make the results of tests of various classes of engines as actually operated in power houses a matter of considerable interest. During the past seven or eight years I have had parties of students under my direction make tests of a great number of power stations. The average results are usually about 40 per cent. higher than the best results which are obtained with a steady load, and this is probably to be considered about the best economy attainable in power stations under present conditions of operation.

The general conclusions to be drawn from the discussion is that in selecting engines for power-house work it is generally profitable as an investment to take engines of the best class. It is probable that the compound condensing engine, when consideration is given to first cost and economy of operation, is the type best adapted for power-house work under present conditions. It can, however, be considered as certain that with slight increase in steam pressure the triple or quadruple-expansion engine may become much more desirable. In general any improvement which in reality does increase the economy of operation is desirable and profitable.

BOILERS FOR ELECTRIC POWER PLANTS.

BY R. A. DOUGLASS.

The writer is often asked what, in his opinion, is the best kind of a boiler for an electric power plant; and in reply has to confess ignorance. Some writers find this question easy, and are able to answer it positively and categorically, saying that for a street railway power station, supplying a city service, the boilers should be so-and-so; that for a similar station feeding a suburban line, they should be different in this or that special particular; that for an electric light plant there is nothing like something else that they tell all about, definitely and specifically; and so on. Now, I admire the powers of observation and reflection which enable these gentlemen to render so final and unequivocal an answer, and I wish that I possessed those powers, and could give an equally simple formula for disposing of the difficulties and perplexities that beset the man who has that problem before him; but unfortunately I do not possess the faculty of so readily prescribing offhand for the various cases met in practice. I shall therefore merely call attention to some of the things that have troubled me in such cases.

The two items that naturally demand attention at the very outset are the first cost of the boiler plant and the subsequent economy of the selected type of boiler in every-day running. There can be no doubt that the common horizontal tubular boiler is one of the cheapest types, so far as first cost is concerned, perhaps the very cheapest, for a given output of power. This will doubtless be conceded even by the manufacturers of water-tube boilers; and the fact that the decision is not given once for all to the horizontal tubular type shows that the item of first cost cannot be regarded as of paramount importance. There are so many other points to be taken into account, that the first cost should be decisive only when the other advantages and disadvantages of the respective types are so equally balanced that a decision on any ground other than first cost is difficult.

Passing to the question of economy of running, the case is very different. The economical generation of steam is certainly of the highest importance, since the coal bills cannot be paid once for all, like the first cost of the boiler; they keep coming to us right along, and sometimes they are unpleasantly and unexpectedly large and frequent. The importance of efficiency in a boiler is therefore admitted just as generally as is the relative unimportance of first cost (within reasonable limits, of course); but while this is admitted as a general proposition, when we come to look into the matter more minutely, in the hope that efficiency may be the golden key that we are after, we find that there is practically no agreement at all among engineers as to which particular type of boiler is most efficient. Every type of proprietary boiler, whatsoever its principle of construction and operation, has its warm friends and advocates, who earnestly and honestly urge its claims in this respect, and produce copies of tests and testimonials, in confusing profusion, to substantiate these claims.

The great majority of the tests that have been made are unsatisfactory, to my mind, because they were necessarily carried out under varying conditions. The only perfectly fair way to compare efficiencies would be to set up all the different types of boilers in some one place, and then test them all under conditions as nearly identical as possible, running each boiler at the same pressure, feeding it with water at a standard temperature, firing them all with the same kind of fuel, pushing each one to the exact capacity for which its makers recommend it, and having all the boilers handled by men of equal skill. It has seldom been possible to carry out a comparative test in this systematic way—never, in fact, except in connection with some great exposition, like the one at Philadelphia in 1876, or the one at Chicago in 1893; and even when such tests are made, their results are not, to my mind, entirely satisfactory.

A good deal depends upon the personalities of the men who have the boilers under their immediate control; and I doubt very much indeed if one of those big comparative tests could be repeated, with a different set of men in charge, or even with the same men at some other time, so as to show the same results, on the second attempt, as were obtained on the first one. And then, after all, what we are interested in, in a practical way, is not what a boiler can be made to yield when it is fixed up to do its best, and in the hands of an expert fireman, but what it can do when covered with soot on the outside and with scale of an uncertain thickness on the inside, and is being run with an indifferent kind of fuel, by a fireman who is perhaps more than indifferent. We conclude, therefore, that although the efficiency of a boiler is of great importance, no data are at hand that will justify a general statement that this or that particular type of boiler is the most efficient one.

But although a sweeping decision cannot be given on the basis of superior efficiency to any one type of boiler, yet there may sometimes be special conditions to be met which enable one to foresee that in these particular cases some one type of boiler is likely to prove itself more efficient than some other type. There is no doubt, for example, that the proper management of a sectional water-tube boiler calls for a somewhat more intelligent and skilful class of help than the common horizontal tubular boiler does. This is not necessarily against the water-tube type, for where it has other compensating advantages, it may be eminently profitable to install this type, and pay the help in charge a little more, in order to secure the best class possible. Of course, I do not mean that a water-tube boiler requires a master mechanic to run it; yet my observation has taught me that there should be some difference in this respect, as a water-tube boiler, however excellent it may be, is undeniably a more complicated apparatus, and needs to be correctly understood by the man in charge. In country stations, or in other places where the general class of labor, so far as the mechanical trades are concerned, is perhaps a little lower on the average than in cities, this point should be borne in mind.

One of the most important elements to be considered in determining the type of boiler to be used, is the kind of feed water that is available; for this has a bearing both upon the efficiency of the boiler and upon its durability. If a good, pure water can be had, which is reasonably free from solid matter, it is possible to run almost any type of boiler efficiently without serious trouble; but when the water inclines to the other extreme, so that the boiler has to be opened at frequent intervals and the scale removed by a scraper and a hoe and a bucket, the case is very different. In a case like this, the horizontal tubular boiler has advantages that none of the other types can offer. It is as accessible for cleaning and examination as any boiler can be, and its comparatively simple construction, with few joints to keep tight, is greatly in its favor. It is often said that sectional boilers do not deposit scale to any serious extent, on account of the rapid circulation that prevails within them; but I cannot subscribe to this opinion, because I have seen altogether too many cases in which the tubes and other parts of such boilers have been badly burned by the deposit of scale within them.

Rapid circulation is a valuable feature in a boiler, but it cannot prevent the lodgment of scale upon the heating surfaces. My own experience has been that when the water is very bad, sectional water-tube boilers are practically out of the question; whereas, it is possible to run a common horizontal tubular boiler with water of almost any character, although even with this type pure water is immeasurably preferable. Sectional boilers, when used with very bad water, are almost certain to fall off greatly in efficiency on account of the difficulty of removing scale from them, and they also give a good deal of trouble under such circumstances both from leakage at their joints and from the burning and bursting of their tubes; while the common horizontal tubular type, owing to its greater simplicity and accessibility, can be managed with much less likelihood of trouble.

It might be supposed that the feed-water question would not be of much importance in cities, where the supply is usually reasonably soft and pure. The charges for city water are often so high, however, that manufacturers prefer to sink a driven well, or to obtain the required water from almost any other source, rather than to draw it from the city mains. I have one plant in mind where a supply of good soft and pure city water is not used in the boilers on account of the high rates that are charged, the superintendent finding it more profitable to get his feed water from an abominable driven well on the premises, buy scale preventives, and to actually replace his boilers with new ones every seven or eight years, rather than to pay the exorbitant charges that are demanded of him for the city service. I mention this simply to call attention to the fact that the water-supply problem is not always as simple as it looks, and that even when good soft water is at hand, it does not always pay to use it.

While speaking of the starting of the joints and the bursting of the tubes of water-tube boilers, I may touch for a moment upon the question of boiler explosions. It is often urged, in favor of sectional boilers, that they are free from liability to disastrous explosions; and there is obviously much truth in this claim, so far as large destruction of property is concerned, although I think that in the matter of personal injury and loss of life the balance is in favor of the horizontal tubular. The bursting of a water tube is not so spectacular an event as the raising of a roof, but it all amounts to pretty much the same thing to the poor devil who has the fire blown out of the furnace upon him, and the contents of the boiler discharged over him. The bursting of water tubes, with the consequent burning and scalding of attendants, is a good deal more common than is ordinarily supposed; and if we take account of the number of sectional boilers that are in use, as compared with the number of horizontal tubulars, it is highly probable that the odds would be against the sectional type.

One feature of the sectional boiler which is especially valuable on occasion is the rapidity with which it can be fired up. Containing a relatively small quantity of water, together with a large heating surface, such a boiler can be put into service very quickly, and in time of emergency this feature is often of exceeding value. It should not be forgotten, however, that this very qualification imposes upon the fireman an additional responsibility in the way of watching his water level; for a boiler that can be fired up very quickly will also lose its water quickly, and if the fireman is not watchful an unexpected and heavy call for steam may cause the water level to fall far enough to allow the boiler to be burned before he knows that anything unusual is afoot. A large body of water is desirable, when the load on a boiler is likely to vary rapidly, since it acts upon the boiler very much as a heavy flywheel acts upon an engine, making the action steadier and lessening the liability to both low water and priming. Unfortunately this feature is incompatible with a quick-steaming capacity; and in the practical selection of a boiler we have to draw a line somewhere, so as to obtain, as far as possible, the combination of a satisfactory body of water with a satisfactory steaming facility, the precise selection being determined, or at least guided to a great extent, by the nature of the work that the boiler is to do.

When the load varies in a regular manner, say from hour to hour during the day, so that one may know for a considerable time in advance just about what power will be required, facility in steaming-up is not of so much importance as it is in cases where the load is liable to irregular changes which cannot be predicted. A large body of water in a boiler may sometimes be a source of loss of heat in plants where the load is heavy for only a few hours out of the twenty-four, unless care is taken to prevent such loss; because in order to get such a boiler into service we have to heat a large mass of water to a high temperature, and then, after using the boiler for a short time, we have all this heat in the water "left on our hands," so to speak. Of course this hot water might be used to feed the other boilers in the battery; but that would not be good practice, because it is a bad plan to draw off water from the boiler while it is in commission, even though it be idle. Mistakes happen often enough without deliberately inviting them.

It is much better to let the fires burn out pretty well as the time for putting the boiler out of service approaches. They should then be banked, and the boiler should be shut off from the rest of the battery entirely, with its damper, fire-doors and ash-pit doors closed. The heated walls of the setting will then radiate heat to the boiler for a long time, so that the pressure within it will probably run up a little for a while instead of down; and if the setting is in good condition, there ought to still be a considerable pressure on the boiler when it is wanted again, say the next day. It might be thought that a boiler would become badly pitted if treated in this way; but, the writer knows of no special trouble of this sort that has been experienced with boilers that are used every day and well protected against radiation. A boiler with a water leg (such as the locomotive type or the upright, internally-fired type) will sometimes pit in the water leg under these circumstances, but other types give little or no trouble when used as described.

Having said considerable that might be interpreted as adverse comment upon the water-tube boiler, I want to say a few words, now, about certain of the positive advantages of boilers of this kind. In the first place, water-tube boilers are built, for the most part, by firms who have good reputations to maintain; and therefore the purchaser may be reasonably sure of getting as good workmanship and material as he is willing to pay for. That feature is certainly worthy of attention. Another point in favor of the water-tube boiler is that its parts are all small in diameter (as compared with the shell of a fire-tube boiler), so that it is mechanically possible to build such boilers to withstand a very high pressure, without making the parts so thick as to offer serious obstruction to the transmission of heat; this is of constantly increasing importance, because of the tendency toward the use of higher and higher pressures. The facility with which sectional boilers may be conveyed to places difficult of access is sometimes of a good deal of importance also. They can be transported in parts and assembled and erected on the spot, whereas the horizontal tubular, and other boilers built with a main shell, must be assembled in a shop and transported in almost complete form. Water-tube boilers, too, are quite well adapted by their mechanical construction to the use of mechanical stokers; and this is certainly in their favor, when the use of such stokers is contemplated.

In addition to the foregoing, another feature, which is often of the greatest importance in cities where land is valuable and power-stations have to be built on the sky-scraper principle, is the light weight of water-tube boilers per horse-power of output. In such cases the tendency is to put the engines on the ground-floor, where their foundations may be more solid, and put the boilers on one of the upper floors, usually on the very top one. When this arrangement of the plant is adopted, it is necessary that the weight of the boilers should be as small as practicable. As the water-tube boiler is much lighter, per horse-power of capacity, than the horizontal tubular, it has a very great advantage under the conditions mentioned.

The question of repairs is one that demands thorough consideration; no matter how carefully a plant may be managed, repairs are just as certain as death and taxes. In general, it may be said that repairs upon a horizontal tubular boiler, or a vertical boiler of the more usual form, may be made without trouble by any local boiler-maker; even if he does not happen to have on hand the exact kind of repair stock required, it may almost always be found near-by without delay of any consequence. Moreover, there are usually several good firms available to do such work, except in remote country places; and it is therefore easy to get the work done at a reasonably low figure. All this applies equally well to certain kinds of repairs that have to be made upon proprietary boilers; but there are also certain other kinds of repairs required by these boilers from time to time of which the reverse holds true. Some of these can be satisfactorily made only by men skilled at this particular sort of work; and this means that such repairs are bound to be more expensive than those of corresponding gravity upon the non-proprietary types, not only because the more skilled laborer can demand and is worth higher compensation, but because the element of competition is practically done away with, since there will probably be few firms within reasonable distance who can undertake the work at all. Certain of the repairs required by proprietary boilers (whether they are of the water-tube type or not) also call not only for greater skill on the part of the workman, but also for special tools, without which no workman, however skillful, can do a really good job.

Boilers with special parts which can only be duplicated by the makers should be put in only after careful consideration of the time that would be required to obtain such parts from the nearest agency or storehouse of the manufacturers of this type of boiler. For example, a boiler built in or near New York City would be free from objection on this score, if it was to be erected, say, in Brooklyn or in Newark; but it might be unwise to adopt this same type of boiler for service in Nevada, unless the manufacturers had previously established a depot in that section of the country, from which any desired part could be obtained on short notice. This objection can be overcome to some extent by keeping on hand at least one duplicate of every part that might perhaps be required; but my own experience indicates that this is a hard thing to do, since the part that is wanted is usually something that has been overlooked, or used up and not replaced, through thoughtlessness, or because it was nobody's job in particular to see that the set of duplicate parts on hand was kept complete. The manufacturers of some of the better-known water-tube boilers have agencies in most of the large cities, from which parts can be had without delay, and in such cases the foregoing argument loses much of its force; but in putting in a boiler of this type, it is always wisest to find out just what can be guaranteed by the builders in the way of furnishing any part of the boiler in double-quick time.

I regret that I have not been able to make more specific recommendations concerning the installation of boilers in electric power plants; but the problem involves so many distinct elements that more definite statements are not practicable unless an exhaustive list of assumed conditions could be discussed, which space limitation forbids. In general it may be said, that the selection of boilers for an electric station is not a radically different problem from the corresponding one of selecting boilers for any other kind of a plant where hard and somewhat irregular service is required; hence the problem we have been discussing has no solution based solely upon the peculiarities of the electric service.

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STOKING IN CENTRAL STATIONS.

BY JAMES F. HOBART.

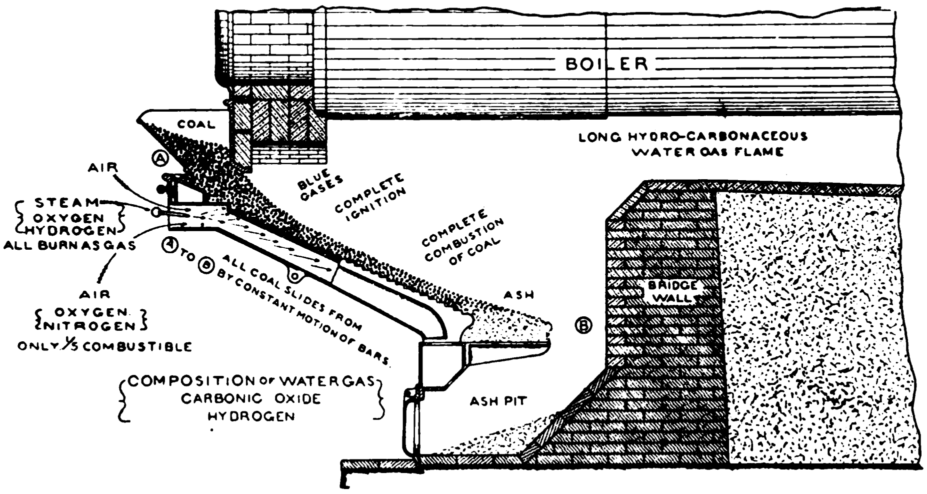

FIG. 1.—PROCESS OF COMBUSTION.

In the process of supplying the necessary quality of coal to a steam boiler, this process being commonly known as stoking, firing or baiting, it is desired to put exactly the necessary quantity of coal into the furnace, distribute the same evenly and quickly over the grates without opening a furnace door to admit a quantity of cold air, which may impinge directly upon the hot plates of the boiler to their disadvantage. Hand firing is the most common method of stoking, and it is also the worst in every particular. The coal is not spread evenly, unless the fireman has acquired exceedingly great skill, and the admission of coal is so irregular that there is frequently a surplus of fuel in the furnace; such surplus is often followed by a "famine," when there is too little coal on the fire, and the steam pressure and economy suffer alike thereby. Various methods of overcoming the evils of hand firing have been tried from time to time, and some of the best known types of mechanical stockers will be described in this article. But first, I want to say something about the action of coal and heat in the boiler furnace, that the action of a stoker may be more intelligently understood. Fig. 1, therefore, is presented to show the process of combustion as the fuel passes through the different stages upon a grate.

It will be seen that the opening to the grate is at all times closed by a body of green coal, through which no air, or at least a very small quantity, can enter the furnace. It will also be noted that air is forced through the coal by means of steam jets. It will be taken exception to by some that the use of a steam jet for this purpose is wasteful, and that a blower would be better. To this argument, I will submit the results of a test made by the manufacturers of the Wilkinson stoker, upon whose apparatus the diagram shown by Fig. 1 was constructed. Tests made with a boiler operated at 57 per cent above its rating showed that the steam jet blast evaporated 10.15 pounds of coal, while the blower blast evaporated 9.33 pounds of water with the same amount of coal, under the same boiler. In both cases, the same amount of pressure of blast was used, the same quality of coal, and all the conditions were the same as far as possible.

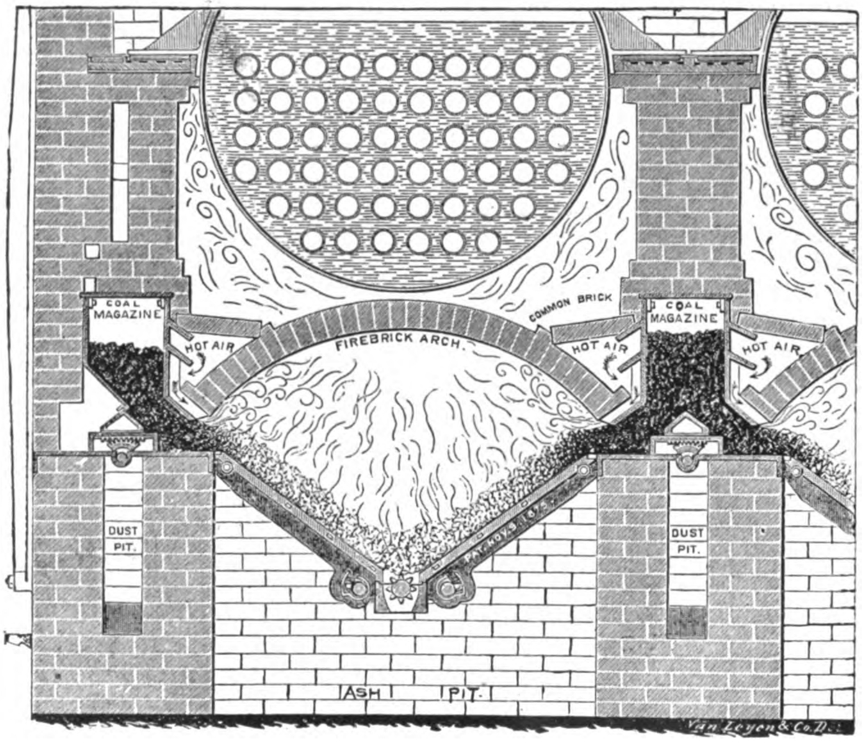

FIG. 2.—SIDE-FEED AUTOMATIC FURNACE.

The diagram shows how the coal passes into the furnace by constant motion of the grate bars, and gives off the blue gases upon its first contact with heat. Then follows the region of complete ignition, then the condition of complete combustion, and the final condition of ash resting upon the grates of the furnace. The combustion chamber over the bridge wall is shown filled with flame arising from the combustion of water gas, produced by the combination of the three stages of coal heating and burning. The composition of water gas is shown to be carbonic oxide and hydrogen.

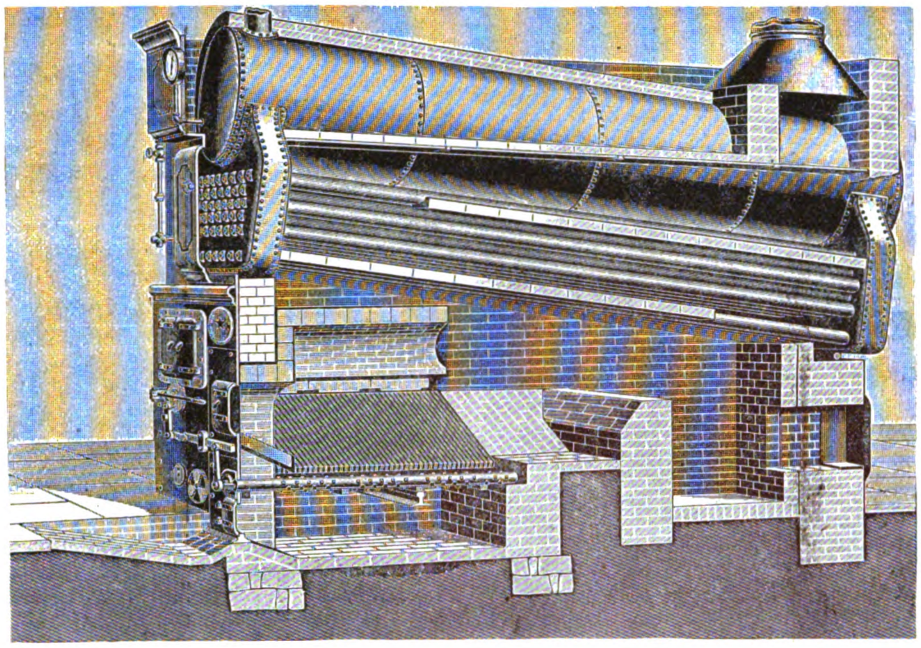

FIG. 3.—SIDE-FEED AUTOMATIC FURNACE.

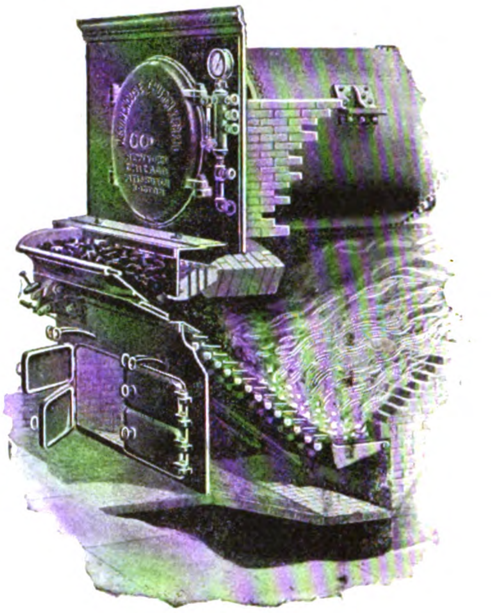

FIG. 4.—FRONT-FEED "STAIRWAY" STOKER.

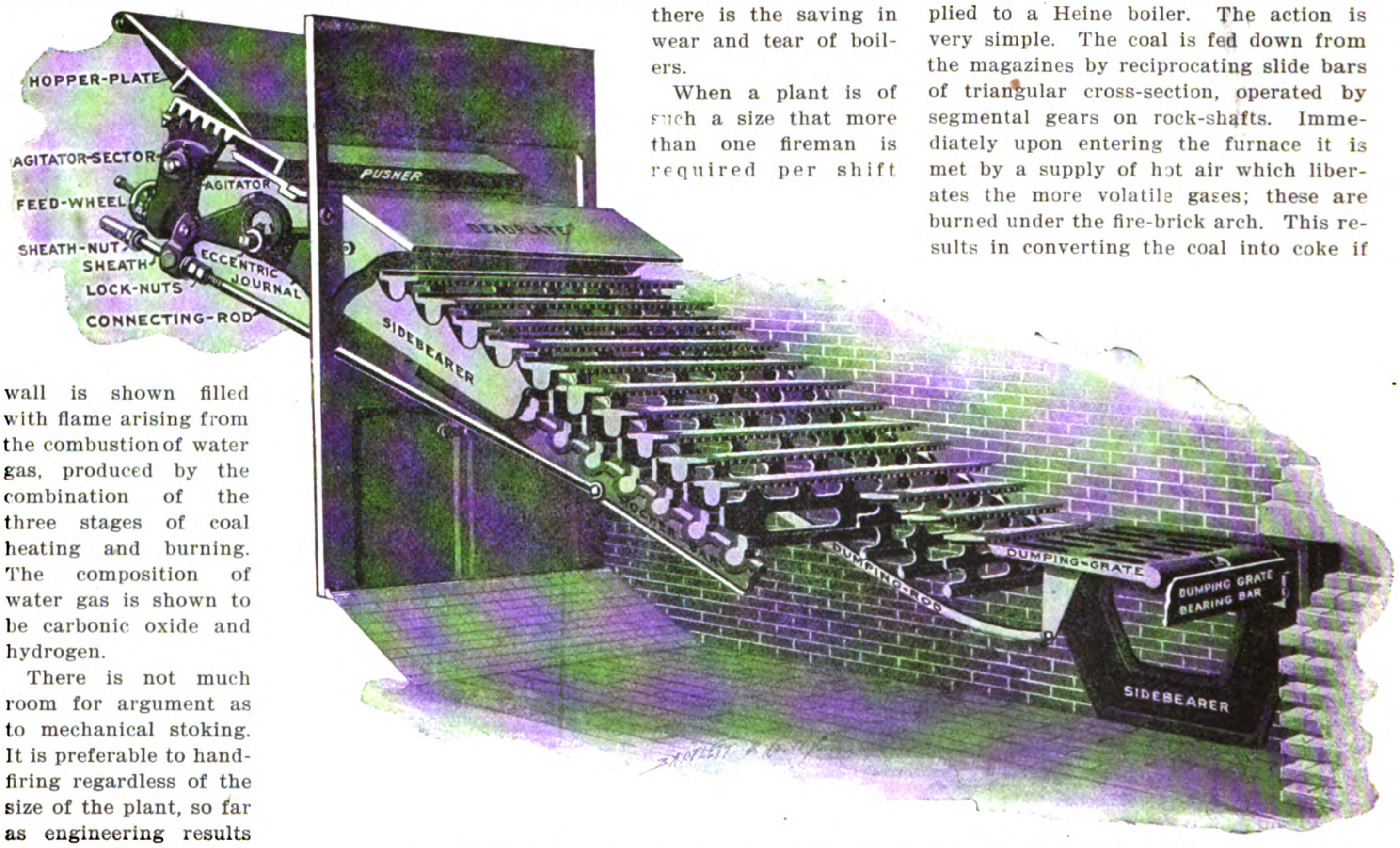

FIG. 5.—FRONT-FEED "STAIRWAY" STOKER, VIEWED FROM INTERIOR OF FURNACE.

There is not much room for argument as to mechanical stoking. It is preferable to hand-firing regardless of the size of the plant, so far as engineering results are concerned. The financial desirability depends somewhat upon the size of the plant. On very small plants there is no saving to be effected by mechanical stoking, as the interest and depreciation on the apparatus will nullify any saving due to more equable firing and decrease in boiler depreciation. For plants big enough to keep one fireman fairly busy there is no saving in labor by using the mechanical stoker, but the superior service and better treatment of the boilers make it much more desirable than hand firing; the current expense is about the same and there is the saving in wear and tear of boilers.

When a plant is of such a size that more than one fireman is required per shift for hand stoking, then the superiority of the mechanical arrangement is not open to argument; it is a foregone conclusion—provided a judicious selection of stoker be made. In this connection it may be of interest to briefly consider the typical constructions now in use. There are four general classes; side-faced "incline" type; front-feed "stairway" type; front-feed chain grate, and under-feed.

Fig. 2 gives a front view of the Murphy side-feed stoker and furnace, or, as the builders prefer to call it, automatic smokeless furnace; Fig. 3 shows this type applied to a Heine boiler. The action is very simple. The coal is fed down from the magazines by reciprocating slide bars of triangular cross-section, operated by segmental gears on rock-shafts. Immediately upon entering the furnace it is met by a supply of hot air which liberates the more volatile gases; these are burned under the fire-brick arch. This results in converting the coal into coke if the proper supply of air has been admitted, and the coke burns on the inclined grate with practically no smoke. The supply of air is regulated by means of dampers in the front of the furnace (see Fig. 3). The grates are kept constantly in motion by two rock-shafts located near the bottom of the inclines. Between the two grates, at the foot of the inclines, is a revolving clinker-breaker, which crushes the clinkers and allows them to drop through to the ash-pit.

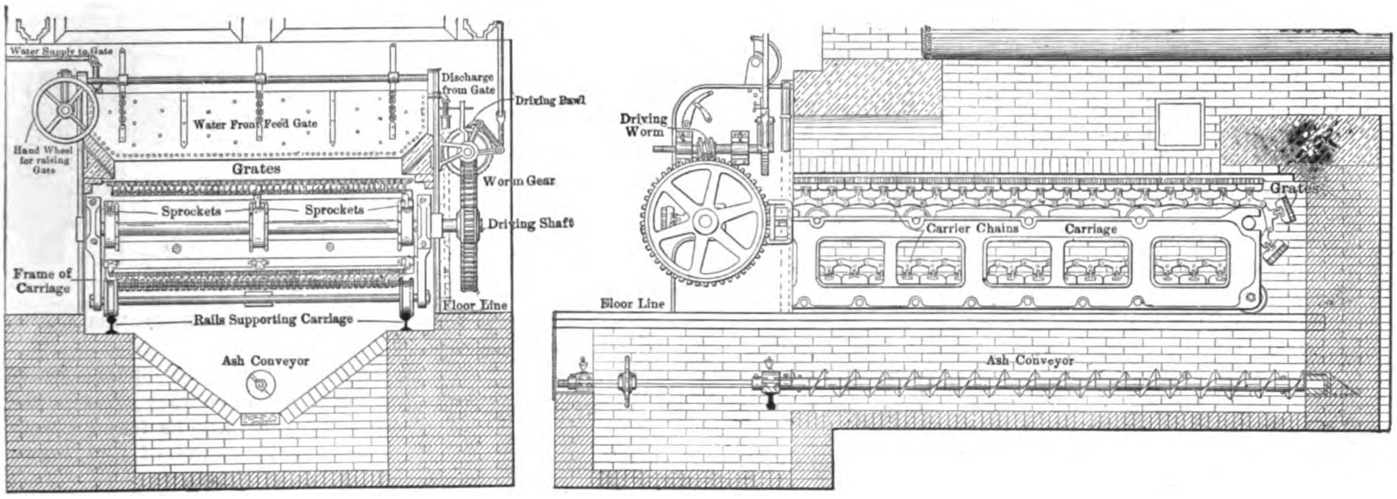

FIG. 6.—FRONT-FEED AUTOMATIC CHAIN-GRATE STOKER.

Fig. 4 shows a front-feed stoker of the "stairway" type—the Roney. The fuel is delivered to the hopper plate and passes by gravity beyond the pusher plate, which reciprocates back and forth and pushes the coal in over the bed plate to the rocking grate bars. These grate bars rock to and fro so as to urge the coal gradually down the incline during the process of combustion, until finally the ash is deposited on the dumping grate. When anthracite coal is used the stoker is fitted with a guard which prevents the coal from sliding down when the dumping grate is lowered to dispose of the ash. The grate bars can be inspected at any time from the front of the furnace and clinkers may be dislodged as they form by simply pushing them off the grate. The doors through which inspection and cleaning, if it should ever be necessary, are accomplished, are below the fire, so that any air admitted cannot impinge upon the boiler without first passing through the fire and becoming heated. A coking arch of fire brick, a small section of which is shown in Fig. 5, is sprung across the furnace over the upper part of the grate, and forms a reverberatory gas producer and furnace, the function of which is to coke the fresh fuel as it enters and to release its gases as above described. This type of stoker may be used with any kind of fuel.

A typical chain-grate stoker, the Playford, is illustrated by Fig. 6. In this apparatus the grate takes the form of a traveling surface similar to that of a rotary planer bed. The fuel is spread upon the grate outside of the furnace, and then moved slowly, grate and all, into the combustion chamber. The fuel is not disturbed or touched after it has been deposited upon the grate. All the ash and clinker are simply dumped off the end of the travelling bed as that mechanism drops down over the back roll to return again to the front for a new charge of coal. There is no prying off of clinkers or digging out of ashes; absolutely nothing to do save to put the coal upon the grate, and this may be done by conveyor and the usual hopper. Again, in case of necessary repairs, the whole grate and all its mechanism can be drawn completely out of the furnace, the whole business being mounted upon trucks and a track for that purpose. There is a worm conveyor underneath the grate which withdraws all the ash and clinker, so that the labor of firing is reduced to dumping coal on the outside of the grate and removing the refuse from the ash-pit.

The grates are sectional, and are designed to burn a large quantity of coal per square foot of surface. The thickness of the fire is controlled by adjusting a gate at the hopper. The fire may also be further controlled by the rate of grate travel, a high rate of combustion being claimed for a travel of 2 ins. a minute. The furnace has a water-front gate which can be raised and lowered for arranging the rate of coal feed as above noted. A worm-and-wheel mechanism, operated by a hand-wheel, is used for this purpose. The water-front gate prevents back-firing of coal in the feed hopper; the water opening to this gate requires no packing. As in the stokers previously described, a fire-brick arch is provided in order to form a combustion chamber for the gases liberated during the coking of the fresh coal.

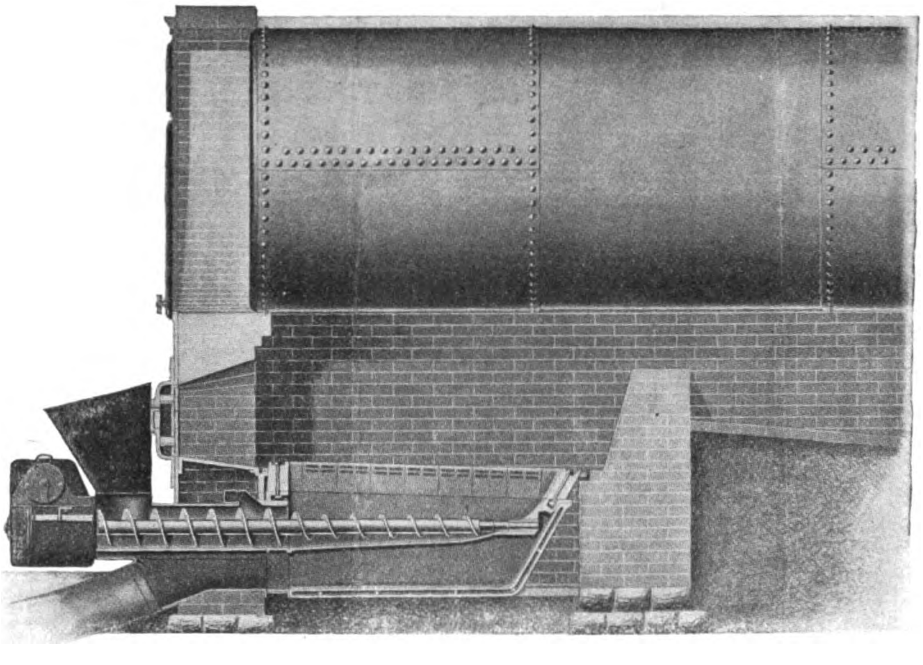

FIG. 7.—SCREW-FEED UNDER-DELIVERY STOKER.

Fig. 7 represents a form of stoker, known as the American, which is radically different from all three of the preceding types. It is of the under-feeding type, the fresh coal being forced into the furnace underneath the incandescent fuel, causing the hydrogen and other volatile portions of the fuel to be driven through a layer of incandescent coal, and preventing the escape of any gases which would be seen as smoke at the chimney top. This stoker consists of a hopper; a screw, encased to force the fuel from the hopper to the grate. The coal is fed into the hopper, carried by the conveyor to the magazine, which it fills, overflows on both sides, and spreads out upon the sides of the grates.

The delivery is slow and continuous, and as the coal approaches the fire in its upward course it is slowly roasted and coked, and the gases released from it are taken up by the fresh air entering through the tuyeres, which explodes these gases and delivers the coal as coke on the grates above. The continuous feeding gives a "breathing" motion to the coke-bed, thus keeping it open and free for the circulation of air. Each stoker is driven independently by a small steam motor located immediately beneath and in front of the hopper. The motor has a simple reciprocating piston. Its piston carries a cross-head which, by means of connecting links, operates a rocker carrying a pawl, which in turn actuates the ratchet wheel attached to the conveyor shaft. The stoker is thus entirely self-contained, and only needs a steam connection when setting up to render it ready to start.

The combustion over these stokers is such that the entire mass of coke above the tuyere block and over the side grates is ignited. The depth of the bed of burning coke above the tuyere blocks is from 14 to 18 ins. The worm conveyor which forces the coal along is tapered so that it cannot carry all the fuel to the rear of the furnace, even if the coke should form a considerable resistance to the passage of fresh coal. The taper causes a portion of the fuel to be dropped at each inch of advance, simply because the diminishing worm cannot carry it all.

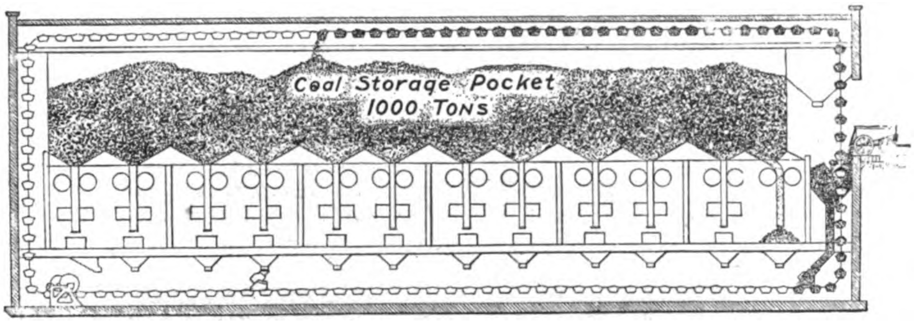

FIG. 1.—CONTINUOUS CONVEYOR SYSTEM.

The non-combustible residue is taken from the furnace in the shape of vitrified clinker. There is practically no soot, and the stokers feed any kind of coal. The refuse is deposited in the form of a coke or crust on the grates next to the wall, being pushed to one side by the feeding of the coal. One open grate against each wall admits air and steam from below (the steam being the exhaust from the motor), and this prevents the clinker from sticking to the walls. To clean the fire a slice-bar is run along the grates and the clinker is raised and drawn out with a hook. The central part of the fire is never disturbed. As the fire doors are never opened except when the fire is to be cleaned (and then the blast is shut off), a rush of cold air is avoided and prevented damaging access to sheets and tubes. The exhaust steam, besides preventing the sticking of the clinker, also keeps the grates cool and prevents their burning out.

There is a wind-box located immediately beneath the conveyor pipe and fitted with an opening beneath the hopper. At this point is connected the piping for the air supply, which is furnished at low pressure by a blower. The other end of the wind-box opens into the air space between the magazine and the outer casing. The upper edge of the magazine is surrounded by tuyeres or air blocks, these being provided with openings for the discharge of air, inwardly and outwardly.

The protection of this apparatus against the fire is complete. Nothing comes in contact with the fire except the tuyeres, and they being made of cast iron, but perforated and protected with a constantly issuing current of air, stand the work much better than the ordinary fire-grate. These castings weigh about 24 pounds each, and under ordinary conditions but about six blocks will be required per year for each stoker. The stokers, complete, weigh about 3500 pounds each.

HANDLING COAL IN CENTRAL STATIONS.

BY JAMES FRANCIS.

The transportation of coal from car or hull to the ash-heap by way of the boiler room cannot be done in one place the same as in another location, with the same degree of efficiency and at the same cost. As in nearly all other branches of engineering, the location and surroundings are controlling factors. In a case within the writer's observation the installation of one large coal-handling plant was a success from the beginning, while another installation of the same machinery, to serve boilers of about the same capacity, proved a flat failure, and the entire installation had to be practically rebuilt before it would answer the purpose for which it was designed. In this case there were local conditions which the engineer had overlooked, and which compelled recognition before the machinery was a success.

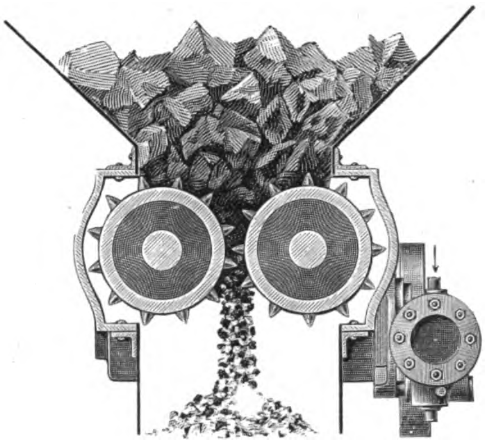

FIG. 2.—COAL CRUSHER.

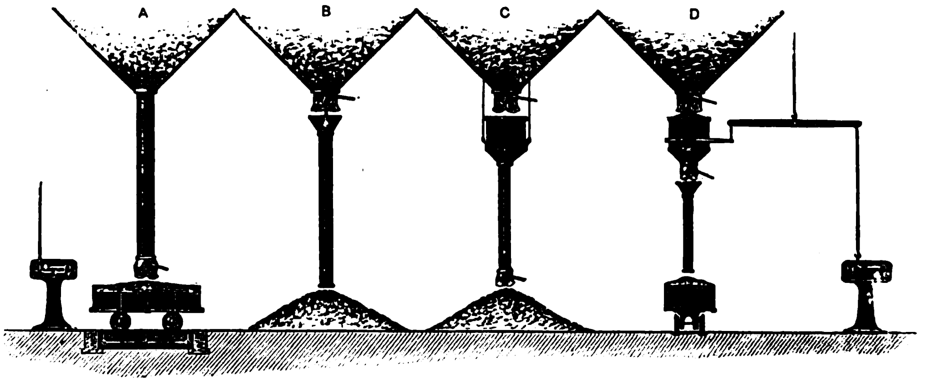

FIG. 3.—DIFFERENT TYPES OF COAL-WEIGHING APPARATUS.

The common conditions under which the work must be done vary exceedingly, but they may generally be found practically the same in plants of like capacity and efficiency. There may be unseen differences, but nevertheless plants can be divided into three classes, in which the work to be done is about the same except in special cases. The three classes are (1) plants of more than 2000-h.p. output; (2) those of 500 to 2000-h.p. output, and (3) plants of less than 500-h.p. output.

In the first class it is essential that unskilled labor be eliminated entirely. There must be no hand work whatever between the car or hull and the ash-car. In a plant of this kind, as well as in the other classes also, the ideal situation is to be able to run cars directly over the coal bins, which in turn must be located high enough to permit of gravity feeding the coal direct to mechanical stokers at the boilers. But it is not in every place that the topography of the situation is such that the railroad and the coal storage can be placed on top of a hill. And even when this can be done it will not answer for coal shipped by vessel. Then the elevator must come into use.

For ordinary city plants, where the coal must be handled by team or by car, the C. W. Hunt rig, shown by Fig. 1, leaves little to be desired. There is a single line of chain conveyor which circles completely around the plant. Coal is dumped in, as shown, from the wagon or railroad car, and if desired a bucket elevator could be arranged in place of the cart so that fuel could be taken direct from tide-water. The coal falls into a hopper below which may be placed a coal cracker (see Fig. 2) if the nature of the fuel requires such apparatus. This is the case when some grades of bituminous coal are used.

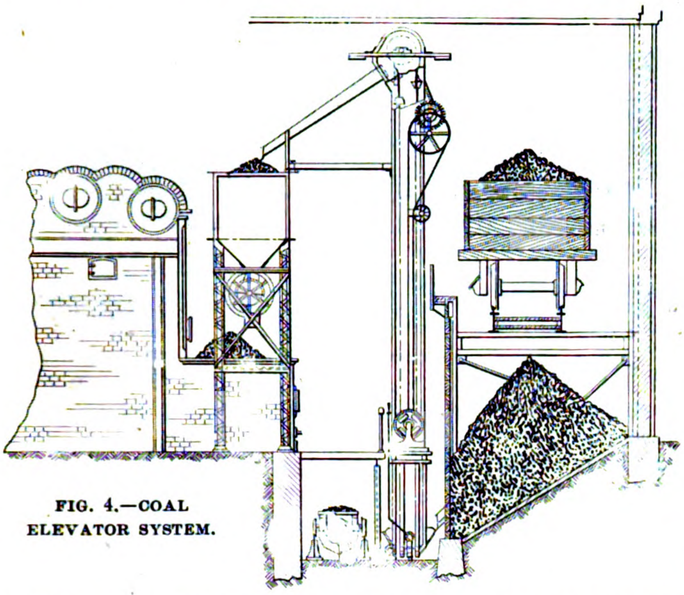

FIG. 4.—COAL ELEVATOR SYSTEM.

Next in the procession is a weighing scale, several forms of which are made by various concerns, and shown by Fig. 3. These weighing machines are automatic or otherwise, as desired, and are also applied directly in front of each boiler, so as to weigh the exact amount that goes to each stoker. The weighed coal may, of course, be delivered upon the floor to be fed by hand if desired. The coal breaker in Fig. 2 is shown driven by an independent engine, but may, of course, be supplied with power by belt or by an electric motor as may be the most convenient. Certainly the second and third methods are the most economical, as the small independent engine is not conducive to economy; convenience is about all it can claim. In the coal-weighing illustration are found all the schemes for either small or large plants. In the first, A, is the regulation floor scale and car; into the car the coal is drawn, and then carried to the boiler, where it is either shoveled directly to the grate, or is dumped upon the floor to be used when wanted. This method is allowable in small plants, and in some of medium size, but should never be tolerated in large installations.

Type B of scale is full automatic in its action, and dumps each scale-full of coal to the stoking floor or hopper, as weighed. The next type, C, weighs the coal into a hopper which holds a considerable quantity, which may be drawn out as wanted from a gate at the bottom of the drop-tube. In style D there is the combination of track-car and independent scale-beam, the weighing being done by drawing a portion of the coal into a weighing hopper, weighing that quantity by hand, and then dropping the weighed coal into the car. Only styles B and C are usually applied to large plants, although style D can be used, of course, in a plant of any size.

Returning again to Fig. 1, the course of the coal may be followed from tip-cart to breaker, weigher and conveyor buckets from which it is dumped into the large coal-storage bins over the boilers to be drawn directly into the stokers, or, as shown at the extreme right of the battery of boilers, upon the floor, as desired. The ashes are taken care of by the same conveyor. As they fall from hoppers at the bottom of each boiler, the ashes are carried up to a bin directly over the weighing machine, whence they can be drawn directly into the cart which brings coal, into a railway car or by means of a chute into a vessel outside the building.

There are many variations possible for this form of apparatus. For instance, in one place, it was necessary to elevate the coal at a distance, carry it underground for many feet, and finally send it to the storage bin as above described. In another instance, the conveying machinery had to be put under the sidewalk and also under a considerable extent of lawn, before the boiler room could be reached.

In another case, the boilers are at some distance from the coal docks and the coal storage is between. Here, a single conveyor takes the coal from a vessel, carries it direct to the weighing hopper over a tram-car in the boiler room, and also dumps the coal in the storage when set to do so. The conveyor can also take coal from the bottom of the storage and deliver it to the weighing hopper. The return fold of the conveyor passes underneath both boiler and coal storage, and can also take along the ashes, delivering them into a hopper from which they may be spouted directly into a coal barge. In this case the ash-delivery and the coal intake from the outside hoist are close together and the conveyor passes around quite a number of bends and angles before it covers the full length of its travel.

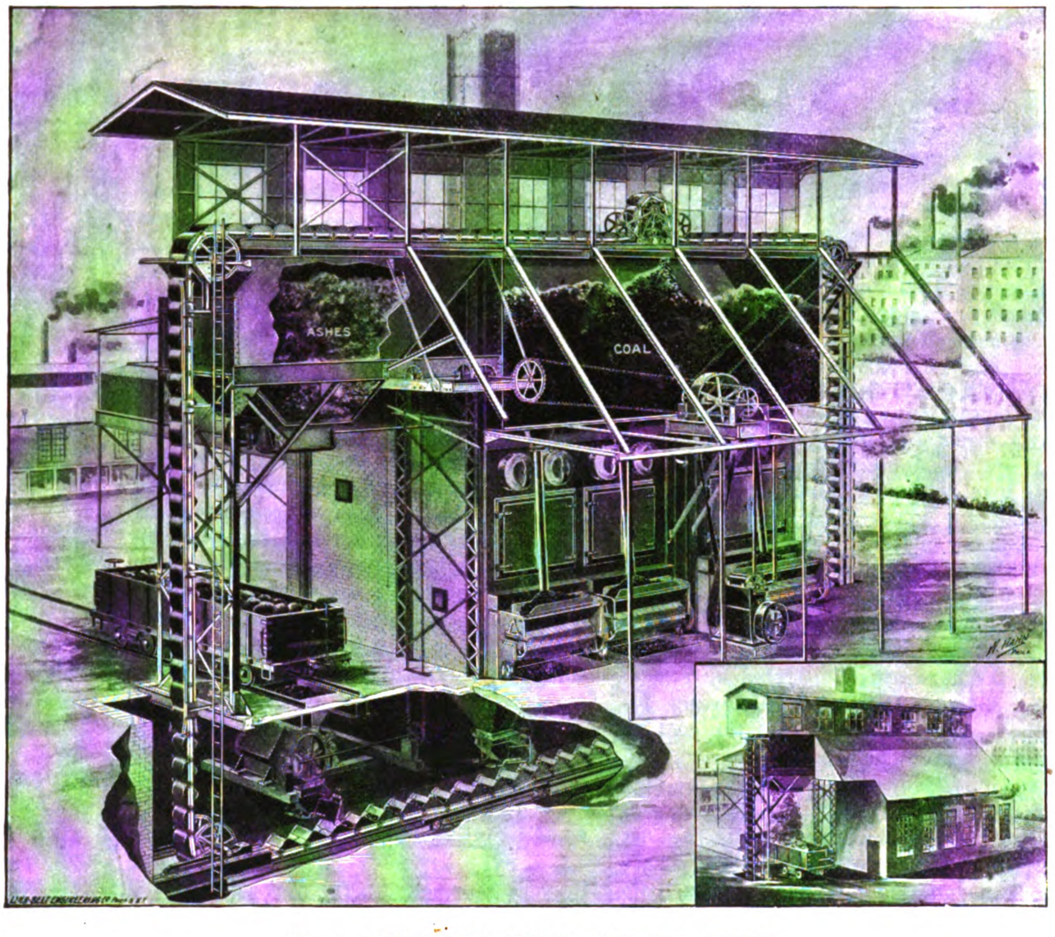

FIG. 5.—CONTINUOUS BUCKET CONVEYOR SYSTEM.

The conveyor is the key-note of the coal-handling business, and may be made to take a supply from several hoppers located below a railroad track, there being hoppers enough to take several carloads at the same time from cars shackled together. Also the same conveyor which takes coal from almost a whole train of cars can be made to take care of the ashes, and to deliver them into a bin placed high enough in the air to allow the ashes to be chuted into railway cars. Still another conveyor arrangement takes coal from a bin into which it is dumped from railroad cars, and carries the fuel to either of two elevated bins, from which it is chuted direct to the boilers to be supplied.

In plants ranging from 500 to 2000 horsepower, there usually is not an elaborate system of coal handling, the owners usually being satisfied with conveying coal into a bin from which it is wheeled in a barrow to the boilers. Some plants are, however, equipped with as complete coal-handling machinery as the larger ones, but this is the exception, rather than the rule of such things. For this class Heyl & Patterson, of Pittsburg, Pa., have a system embodying a traveling electrically-driven elevator. There is a tank above each boiler, from which coal may be drawn direct to the stoker or the floor. The coal is dumped from cars on the same level with the boilers or lower, and the elevator conveyor is moved along to the opening in front of the boiler needing coal. This apparatus can also be employed with large plants if desired, but it seems particularly well fitted for small installations. Heyl & Patterson also make the apparatus illustrated by Fig. 4, which includes the traveling elevator described. It will be seen that the coal is dumped conveniently below the cars and that a long lever extending from the bottom of the leg to above the working rail on the boiler-room floor permits the device to be conveniently controlled. There is also a dumping car running on a little tramway below the boilers for the purpose of carrying away the ashes, which are dumped directly into the car from hoppers under the boilers.

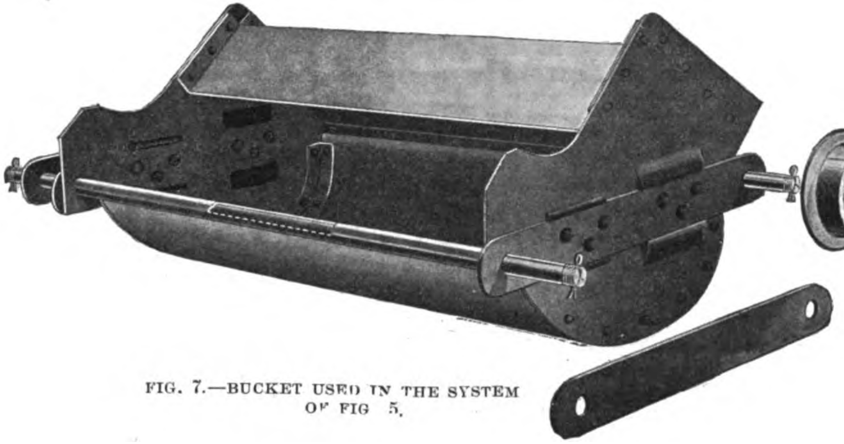

FIG. 7.—BUCKET USED IN THE SYSTEM OF FIG 5.

The Jeffrey Manufacturing Company advocates overhead coal bins, with gravity distribution to each boiler or furnace through the necessary spouting. Ashes are handled with this machinery, and the same conveyor takes care of both fuel and the refuse of combustion, as in the large plant machinery described at the beginning of this article.

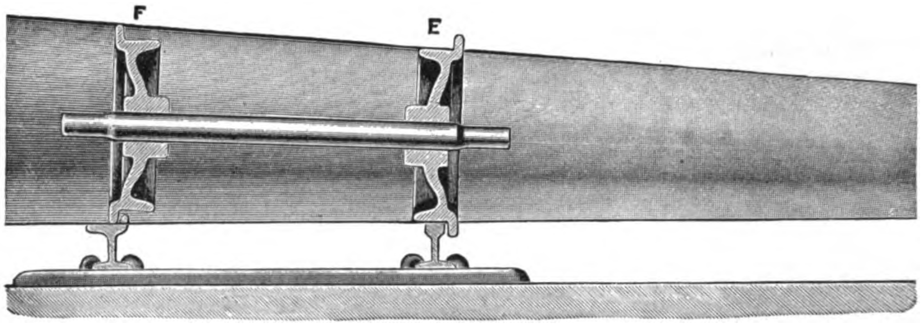

FIG. 6.—METHOD OF REDUCING FRICTION ON TRAMWAY CURVES.

The Link-Belt Manufacturing Company also makes machinery well adapted to handling coal for small and large plants (Fig. 5). Here the "continuous bucket" conveyor is arranged to serve a small plant of two boilers. The coal is stored overhead, and is taken direct from the car by being dumped through a pulverizer or breaker. It will be noted that the coal is carried one side and stored directly over the pair of boilers, while the ashes, handled by the same conveyor, are taken to and stored in a bin directly over the railroad track, so that they may be dumped directly into the same car that brings the coal, if such a proceeding be desirable. In the engraving, the coal is shown chuted directly to the stokers, of which several kinds are shown in order to demonstrate that the system is not restricted to any kind in particular, but is applicable to all. The cut-off underneath one of the boilers is also shown; it is evident that there is a considerable ash storage underneath each grate, so that it is not necessary to handle the ashes for some time when coal is being put in.

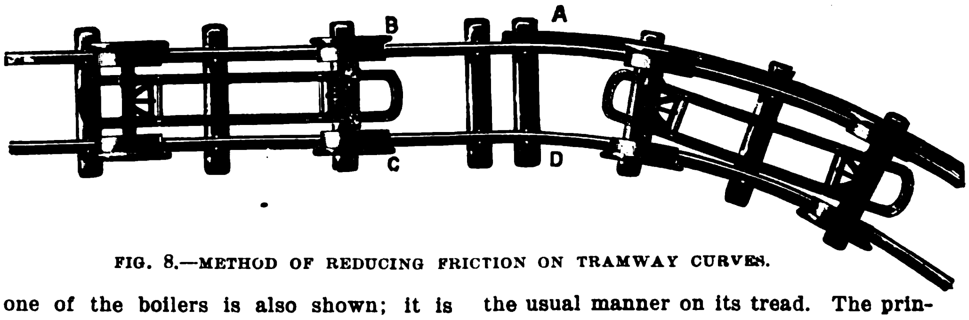

FIG. 8.—METHOD OF REDUCING FRICTION ON TRAMWAY CURVES.

It will be seen that this apparatus is entirely link-belt driven from a small engine located in front of and just above the boilers. Of course if there is a shaft handy, power may be taken direct from it, saving the cost of operating an independent engine, but with an individual prime mover there is always the advantage of being able to handle either coal or ashes when the main engine is not running; sometimes this point is of exceedingly great value. Fig. 7 shows one of the buckets forming a part of this system.

For conveying coal to boilers of very small plants, and, I am sorry to say, of some large ones as well, the wheelbarrow is used far too much; the push-car is a close second, while the tramway, either in the floor or overhead, is neglected to too great an extent. There is no economy in wheeling coal, even for a single 50-h.p. boiler, and some form of railway should be employed when the management cannot be encouraged to put in a conveyor. And as tramways are sometimes put in there is very little comfort in their use, especially when there are many curves in the track. No matter how narrow the gauge of the road, there will be a great amount of power needed to force a loaded car around a curve unless means are employed to obviate the necessity of slipping one of the wheels over the difference between the length of the inner and that of the outer rails.

Two examples are given herewith of methods for decreasing friction when pushing cars around curves. Fig. 6 shows an axle fitted with outside flanged wheels so arranged with rails to fit that the outside wheel runs around the curve on the flange, while the inside wheel travels in the usual manner on its tread. The principle on which these cars turn a curve is well shown by the engraving. A cylinder rolls on a plane in a straight line, without sliding friction. A cone also rolls without sliding friction, but in a circle on a plane. If a pair of wheels rigidly fixed on an axle running on a curve have the same diameter as the cone would have at each rail, they are virtually portions of the cone and the wheels would round the curve without sliding friction, the axles taking a radial position, provided the curve is correctly proportioned to the difference in diameters of tread and flange.

Fig. 8 illustrates the application of the outer flanged wheels to axles pivoted in the center between the wheels, permitting them to take the radial position shown. The result of the arrangement is so obvious that no further description is necessary. Sometimes the scheme is tried of making the axles take a radial position when upon a curve by throwing a lever which puts them radial. This arrangement does not meet the necessity of the case, because the outer rail is longer than the inner one, no matter whether the axles which pass over it are parallel with each other or radial to the curve.

Still another way of passing curves easily may be employed in arranging coal cars for small plants. The wheels may be fitted with inside flanges in the usual way, and the axles placed in the usual bearings. Then one wheel is forced upon the axle while the other wheel is left loose, to run faster or slower as the car goes around a curve. In any case, the movement of the loose wheel on the axle is very slight, therefore there is very little wear either to wheel or axle. This is one of the cheapest and simplest methods of arranging cars for curve work, and leaves very little room for improvement.

Better than the tramway described above for coal handling is the light single rail overhead track, upon which the car can be pushed along with never any trouble from stuff getting on the track or excessive friction due to the binding of the axles on curves. With such an equipment one man can handle a ton of coal in a car with suprising case.

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STEAM PLANT AUXILIARIES.

BY P. C. PERCY.

Every boiler plant should be provided with at least two feed pumps, each capable of supplying the entire plant without overworking. The type of pump to be preferred depends upon the character of the plant. It is safe, however, to make it a rule never to use a direct-acting steam pump unless it is impracticable to use anything else.

Considering first non-condensing equipments. If the plant be too small to justify the use of a fly-wheel pump with variable cut-off at the steam valve, it may be practical to drive a belted pump—simplex, duplex or triplex—from the main engine, or from one of them, if there be several. If this can be arranged, it is greatly preferable to the use of a duplex steam pump, which is about the least desirable piece of machinery known to the writer.

A belted pump requires power only in proportion to the quantity of water delivered + its own friction load; a steam pump of the ordinary type takes a cylinder-full of steam each stroke, regardless of whether its slip is 50 per cent. or 5 per cent., and the worse the slip the faster it must work, aggravating the inefficiency. Take, for example, a pump delivering 5000 lbs. of water an hour against a boiler pressure of 100 lbs. per square inch (14,400 lbs. per square foot). This means 80 cub. ft. of water, and 80 × 14,400 = 1,152,000 foot-pounds of work, an hour, net. Allowing the pump and piping a mechanical efficiency of 80 per cent. and the pump a slip of 10 per cent., and ignoring radiation, the steam used will be 111 cub. ft., or practically 28½ lbs. an hour. This means a duty of a horse-power-hour on about 50 lbs. of steam. A direct-acting steam pump that gave such a result would need a burglar-proof wall built around it. The average duty is about half of this figure, or 100 lbs. of steam per horse-power-hour.

Now, if the slip be assumed to increase to 25 per cent. by reason of leaky valves, the steam consumption will be 63 lbs. per horse-power-hour. The result generally obtained under excellent conditions is about 90 lbs. of steam per horse-power-hour represented by delivered water, which means that the total efficiency of the pump and piping is a trifle under 40 per cent. With losses by radiation and friction, including the pipe friction, of 35 per cent., which is normal, the slip must be about 40 per cent.

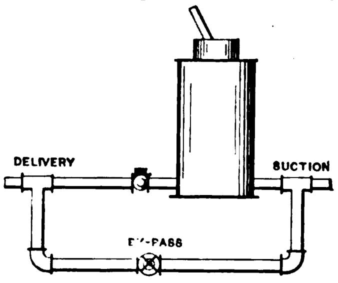

FIG. 1.

A fly-wheel pump manifestly has the advantage of steam expansion, and is therefore greatly superior to the direct pump in economy. A belted pump driven from the main engine has the advantage of both types of steam pump in that it runs at very nearly the steam efficiency of the main engine. Assume a belted pump in the place of the steam pump above mentioned, having a mechanical efficiency of 70 per cent. The power required to drive it up to the delivery specified, practically irrespective of slip, will be 0.83 h.p.; if the engine consumption be 30 lbs., the pump will require about 25 lbs. of steam an hour total, or 43 lbs. per horse-power-hour—less than one-half of the amount required by a duplex steam pump under good normal conditions. The difference is due to slip and radiation, neither of which enter into the efficiency of a belt-driven pump.

The disadvantages of inconvenient location and poor control, however, militate against belt pumps in small stations. The only economical method of regulation is to by-pass the pump, as indicated in Fig. 1. This entails a disproportionately high load when running under light duty. Of course, where water is free and the lift insignificant, a waste valve can be put in the delivery pipe of the pump and the amount of water forced into the boiler or boilers will be regulable by adjusting the waste.

In stations operated by combined water power and steam engines, however, nothing compares with a belt-driven pump for boiler feeding. The water supply, in such a case, should be taken from the penstock or the flume leading to it, so that the pump will have little or no lift, or possibly an assisting supply head. Then its location is immaterial, as a waste valve would be located in the delivery pipe within the boiler room.

For medium-sized (200 to 1000 h.p.) central stations containing alternators, the writer has found it highly convenient and efficient to use a small steam engine to drive a boiler-feed pump and an exciter. The equipment was in duplicate, two small auxiliary engines being provided, each belted to one exciter and one triplex boiler-feed pump. Each exciter was, of course, capable of taking care of all of the alternators and each pump could more than supply every boiler working under forced draft. When this arrangement is used it is preferable, of course, to locate the auxiliary engines as near as possible to the door between the engine and boiler rooms. In the writer's practice the pumps were set in galvanized-iron pans, the edges of which were an inch deep, and a drain pipe carried away all slop water.

The smallest engine ever used by the writer in this way was a 10-h.p. vertical automatic. The duplicate outfits were put in to displace a nest of duplex and simplex steam pumps which were constantly in trouble, the matter of efficiency being secondary. The saving in repairs actually paid for the new equipment within two years; the estimated saving in steam, based on a conceded efficiency of 50 per cent. for the old pumps (which was extravagant) and indicator cards taken from the new equipment ten months after installation, was 18 per cent.

Added to this was the immense convenience and not inconsiderable saving due to supplying the station lights from the exciter. This insured ample illumination around the plant regardless of crippled alternators, which at that time were not quite so reliable as the sun. The small equipment under discussion was installed in 1893, and is running now. A larger one, installed early in 1892, produced such favorable results that when the plant was nearly doubled in 1897 this method was retained in laying out the new equipment.

The capacity of an auxiliary engine used in this manner will be somewhere between 5 and 10 per cent. of the total indicated horse-power of the main engines. The boiler-feed pumps of a non-condensing plant of average size usually require at their plungers about 2¼ per cent. of the power indicated in the engine cylinder; assuming an engine efficiency of 85 per cent., an alternator efficiency of 90 per cent., an efficiency at the exciter of 85 per cent., and a consumption in the fields of the alternators of 3 per cent. of their output, the exciters will require for their driving 4¾ per cent. of the indicated horse-power of the main engines, so that a pump and an exciter, each capable of supplying the whole plant and both driven from one engine, will require that engine to deliver, on the basis assumed, the equivalent of 7 per cent. of the indicated horse-power of the main engines.

The above figures are fairly applicable to medium size plants, rather high for plants above average size, and rather low for plants under the average size. An auxiliary engine capable of developing 10 per cent. of the horse-power developed by the main engines will be ample to drive the boiler-feed pump and exciter for the smallest stations found in practice, and for stations of 500 h.p. and up the auxiliary engine will not need to develop over 6 per cent. of the horse-power of the main engines. It is scarcely necessary to say that the total equipment of auxiliary exciting and pumping plant should be divided into not less than two, and preferably more, units, according to the size of the station. The units should be of such size that if one becomes disabled the other or others can take care of the maximum possible load without crowding.

When a steam plant runs condensing, the type of pump depends first upon the layout of the whole plant. If the heavier portion of the plant is so poorly planned as to render it desirable to use steam pumps in order to apply their exhaust heat to the boiler feed water, then, of course, belt-driven and motor-driven pumps do not enter into consideration. The best practice under such conditions is to employ fly-wheel steam pumps with variable steam cut-off. If the feed water is heated by means of economizers or live-steam heaters, or both, then some discrimination is required in selecting the pumps. It is highly preferable to use belt-driven pumps throughout, provided they can be driven from some economical prime mover, such as the main engine. Where this is not practicable, the choice lies between fly-wheel steam pumps and those electrically driven.

For plants of moderate size, in which the power required by each pump is anywhere from 2 h.p. to 20 h.p., the motor-driven pumps are better. A fly-wheel pump cannot be expected to give better duty than a horse-power-hour on 60 lbs. of steam. Motor-driven pumps having an efficiency of 60 per cent. between the motor terminals and the pump plungers are available. Assuming a simple condensing engine, using 25 lbs. of steam per horse-power-hour, on an average, and dynamos of 90 per cent. average-load efficiency, the steam consumption per horse-power-hour, at the pump plunger, will be 46 1/3 lbs., or nearly 25 per cent. better than the fly-wheel pump. In larger plants the showing is better, of course, for both types, but the electrically-driven pump will have the advantage up to the point where the steam pump becomes a pumping engine consuming about 35 lbs. of steam per horse-power-hour, delivered to the plunger. Here, the two are about on a par, if the main engine is a simple condensing machine. Where a compound-condensing engine is employed, its higher efficiency improves the showing of the motor-driven pump, and the fly-wheel steam pump, to equal it in efficiency, must be capable of giving a horse-power-hour on about 28½ lbs. of steam, which is manifestly an almost unattainable high duty.

When the electrical equipment of a plant is wholly alternating-current apparatus (excepting exciters, of course), the matter becomes somewhat complicated. Induction motors are permissible for driving such pumps as may be operated at constant speed, but are not suitable for variable speeds, nor are they especially desirable for driving pumps at all. A better plan than the use of these motors for this class of service would be to employ for exciters dynamos of sufficient size to supply both the pump motors and the alternator fields. This advice relates, of course, to pumps in alternating-current plants driven solely by condensing engines. The remarks concerning a non-condensing steam plant operated in combination with water wheels apply equally well to condensing plants thus operated.

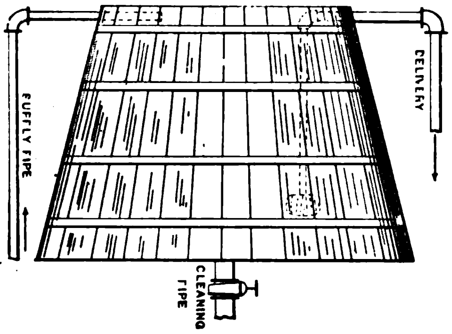

FIG. 2.

It may not be amiss to point out in conclusion that any steam plant should be provided with a reserve tank holding 50 per cent more than enough water to fill one boiler and located above the boiler level. This tank should be covered tightly and kept always full of water. Both the supply and delivery pipes should enter the tank at the top, the delivery pipe being led down to about three-fourths of the depth of the tank and terminating in a strainer. The clearing out pipe should be entirely separate, leading out from the bottom of the tank (see Fig. 2). Also, every steam plant equipment should include one or more absolutely reliable injectors so that the boilers can be supplied, although uneconomically, even if all the pumps go to smash simultaneously. The injectors should be tested at least once a week, and the reserve tank should be emptied, cleaned and refilled once a month.

THE ARRANGEMENT OF CENTRAL-STATION PIPING.

BY WILLIAM D. ENNIS, M. E.

To properly design and install the steam and water piping of a power plant involves expert work and special training. In electric central stations, which represent the highest types of steam engineering, the question of piping is one of great importance. Its efficiency cannot be expressed in per cent like that of a boiler or engine. The losses due to improper design are uncertain but not small. They can be computed only from the difference between the product of known mechanical efficiencies and the pro rata station output.

Intelligent arrangement in this direction not only increases the relative output by proper disposition of condensed steam; but it adds to the effective working of the plant by permitting of proper adaptation of the equipment to the load. It also keeps in view the necessity of occasionally cutting out certain apparatus for the purpose of making repairs without crippling the entire plant.

ARRANGEMENT OF PIPING IN A SMALL LIGHTING PLANT.

In a small lighting or railway plant, say of 250 horse-power, with non-condensing engines, the piping is simple and inexpensive. Take the case illustrated in Fig. 10, where two horizontal boilers and two belted generating sets are employed, the shafts being, as they should be, at right angles to the roof trusses, and parallel to the boiler fronts. Obviously the boilers and engines should be so connected that either of the latter may be operated from either of the former. To do this, a construction analagous to the bus-bars of a switchboard is adopted. This consists of a header into which steam from the boilers is carried, and from which the engine mains are led. The handiest place to locate it, in this particular case, is back of the boilers, between them and the partition wall, as shown.

To compute the size of the header, we must know the work required of it. The two engines, aggregating 250 nominal horse-power, will carry a maximum load of 275 indicated horse-power, say, at the steam pressure to be carried, 100 lbs., and a cut-off at one-quarter stroke. Assume also that they will require 28 lbs. of steam per horse-power-hour. The total steam to be supplied will be $275 \times 28 = 7700$ lbs. per hour. From a steam table we find that 1 lb. of steam at 100 lbs. pressure occupies 3.82 cubic feet. Experience teaches that the best results are obtained by proportioning steam pipes so that the velocity of the fluid shall not exceed 6000 ft. per minute. We therefore have, $7700 \times 3.82 \div 60 = 490.2$ cubic feet of steam to be supplied per minute, and $490.2 \div 6000 = .0817$ square feet of cross-section required in the header, or in square inches, 11.86. As the engines are taking steam during only one-quarter of each revolution, this area must be multiplied by four, giving approximately 48 square inches, which corresponds in area with an 8-in. pipe. This would be the proper size of pipe to use for 275 h.p. total output.

If the header be made equal to the combined areas of the throttles, it would, strictly speaking, be ample for the passage of the steam; but a second useful purpose can be served by making it somewhat larger than this would require. Engines use steam for only a fractional part of each revolution. The effect of a sudden demand through small pipes of limited capacity is to cause the boiler to foam or prime. If the header is made large enough to furnish steam for two or three revolutions, there is no sudden demand upon the boilers, and the steam is delivered uniformly to the header. We might, therefore, fix the size of the header at 10 in. instead of 8 in., in the preceding case.

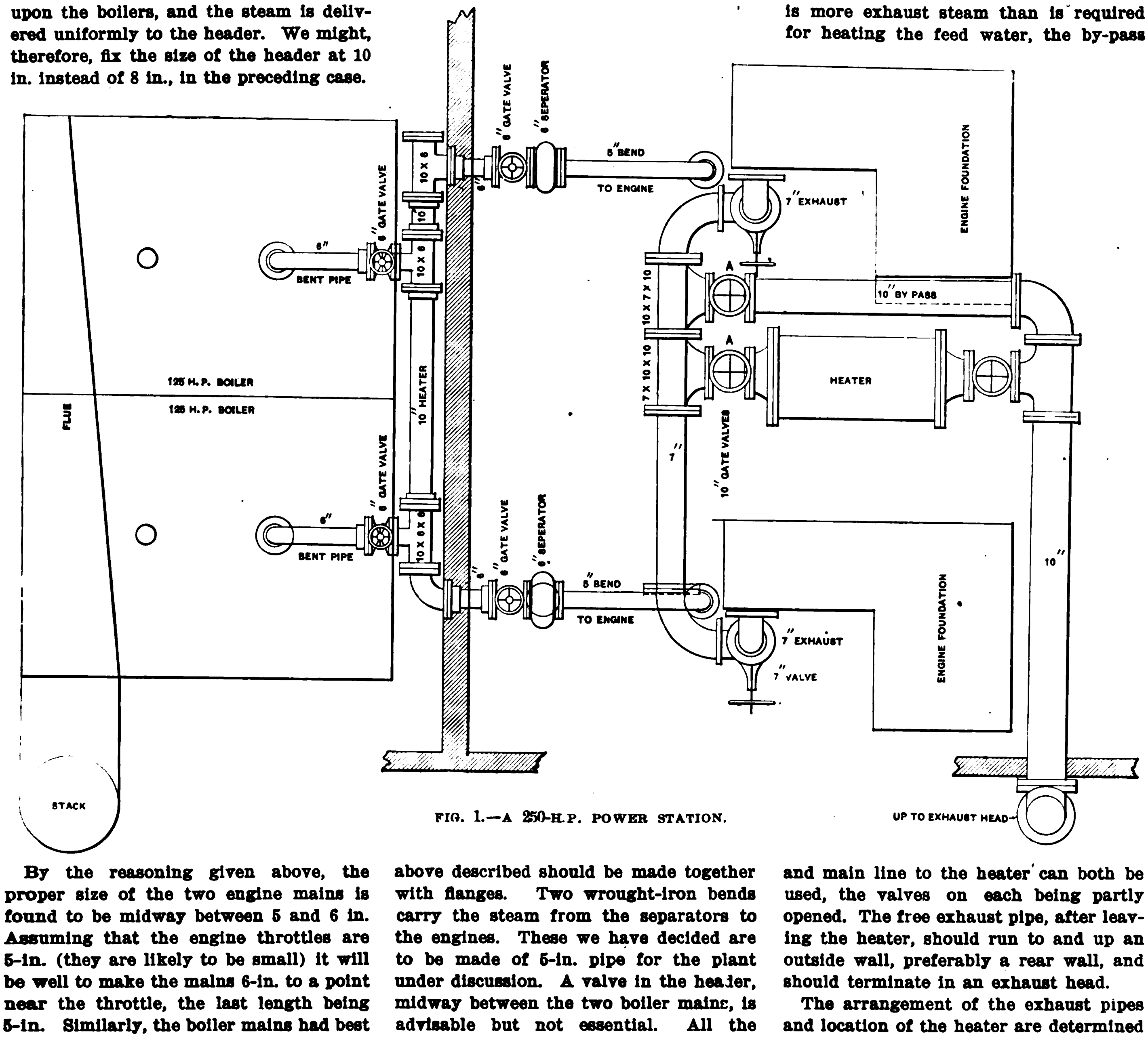

FIG. 1.—A 250-H.P. POWER STATION.

By the reasoning given above, the proper size of the two engine mains is found to be midway between 5 and 6 in. Assuming that the engine throttles are 5-in. (they are likely to be small) it will be well to make the mains 6-in. to a point near the throttle, the last length being 5-in. Similarly, the boiler mains had best be 6-in.

The location of the header should be from 5 to 8 ft. above the boiler nozzles, according to the available head room. The best method of connecting the boilers with the header is by bent pipe, as shown. A shut-off valve for each boiler will of course be required; these should be placed at the highest points of the mains, to avoid the lodgment of condensation. By using flanged Ts on the header the flanged valves can be bolted directly to them, avoiding additional joints. As there is always a possibility that the plant may be enlarged, a blank-flanged T should be left at the end of the header, so that the pipe system can be readily extended. Should the extension be a certainty, the header should be made larger.

The engine mains must be provided with valves and separators. As the former are for use in case of emergency, they should be provided with a quick-opening device. For the same reason, they are placed in the engine room. The separators may bolt directly to the valves, and the whole high-pressure system as above described should be made together with flanges. Two wrought-iron bends carry the steam from the separators to the engines. These we have decided are to be made of 5-in. pipe for the plant under discussion. A valve in the header, midway between the two boiler mains, is advisable but not essential. All the valves thus far indicated should be straight-way iron-body gates, with outside screw, rising spindle and yoke, and the valve in the header, if one is used, should be by-passed.

To support the pipes, the header can be hung from the overhead roof trusses, or if the partition wall is sufficiently thick, it can rest on cast or wrought-iron brackets bolted to this wall. It should be fastened rigidly in directions at right angles to its length, both horizontally and vertically. To provide for expansion, one end should be firmly anchored, so that the movement will be all in one direction and harmless. The bent pipes will take care of their own expansion.

The exhaust pipes for the engines can be run separately or in one main. The latter plan is cheaper, and if used a valve must be furnished on each engine exhaust pipe, so that if one engine is shut down the exhaust steam from the other engine will not back into it. If a feed-water heater is used, the exhaust pipes should be so arranged that the heater may be by-passed if necessary, as shown. If there is more exhaust steam than is required for heating the feed water, the by-pass and main line to the heater can both be used, the valves on each being partly opened. The free exhaust pipe, after leaving the heater, should run to and up an outside wall, preferably a rear wall, and should terminate in an exhaust head.

The arrangement of the exhaust pipes and location of the heater are determined largely by the available room left by the engine foundations. If there is no basement under the engine room, the pipes must be run either in trenches or overhead, both of which practices are objectionable. Where there is basement room, the pipes are usually run downward from the flanges on the side of the cylinder, the foundation being cut away if necessary. They are then offset to clear the latter. The arrangement shown in the illustration is perhaps the simplest for this particular case, but it is well to avoid bringing two exhaust pipes toward each other in a straight line, as is here indicated.

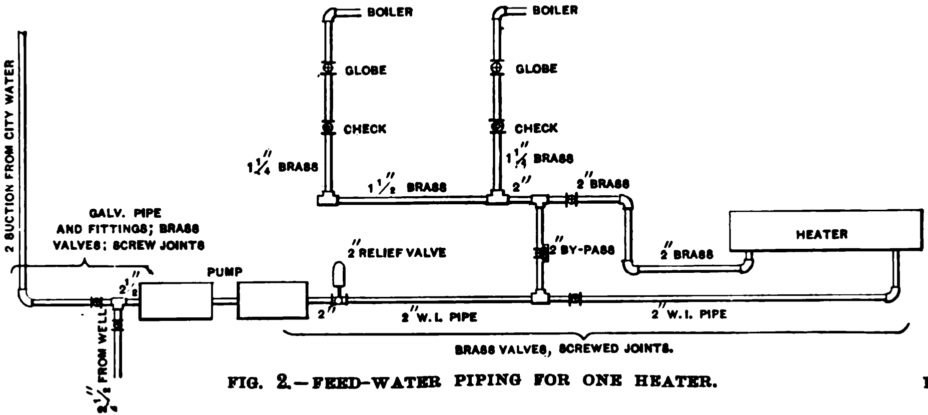
BOILER
GLOBE
CHECK
1¼" BRASS
1½" BRASS
BOILER
GLOBE
CHECK
1¼" BRASS
2"
2" BRASS
2" BY-PASS
2" BRASS
HEATER
2" SUCTION FROM CITY WATER
GALV. PIPE AND FITTINGS; BRASS VALVES; SCREW JOINTS
PUMP
2½"
2"
2" RELIEF VALVE
2" W.I. PIPE
2" W.I. PIPE
BRASS VALVES, SCREWED JOINTS.
2½" FROM WELL

FIG. 2.—FEED-WATER PIPING FOR ONE HEATER.

The sizes of the pipes are calculated as explained above, but the permissible velocity is taken at 4000 ft. per minute and the duration of passage is about half the stroke or revolution. Straight-way valves and flanged fittings should be used, and the pipe may be either wrought iron with screwed flanges or cast iron. The pipe from the foot elbow to the exhaust head may be of galvanized sheet iron. All parts of the exhaust piping are left free to expand, and support is obtained from wrought-iron straps attached to the floor beams above. The exhaust head must be supported from the roof. If wrought metal pipe is used, however, a strong support under the elbow and a light brace near the head will suffice. In this case the entire length of vertical pipe need not be made with flanged joints, ordinary couplings being sufficient excepting at the end connections to head and elbow.

The exhaust pipe from the pump may run to the heater, or to a separate auxiliary heater, or direct to the atmosphere. In country plants it can be carried through the nearest wall, without any riser or exhaust head. In other cases it will be necessary to connect it with the main exhaust. These small steam and exhaust pipes will be connected with screwed joints, the valves used being brass. Small piping must be supported with some care, or it will prove a never-ending source of trouble.

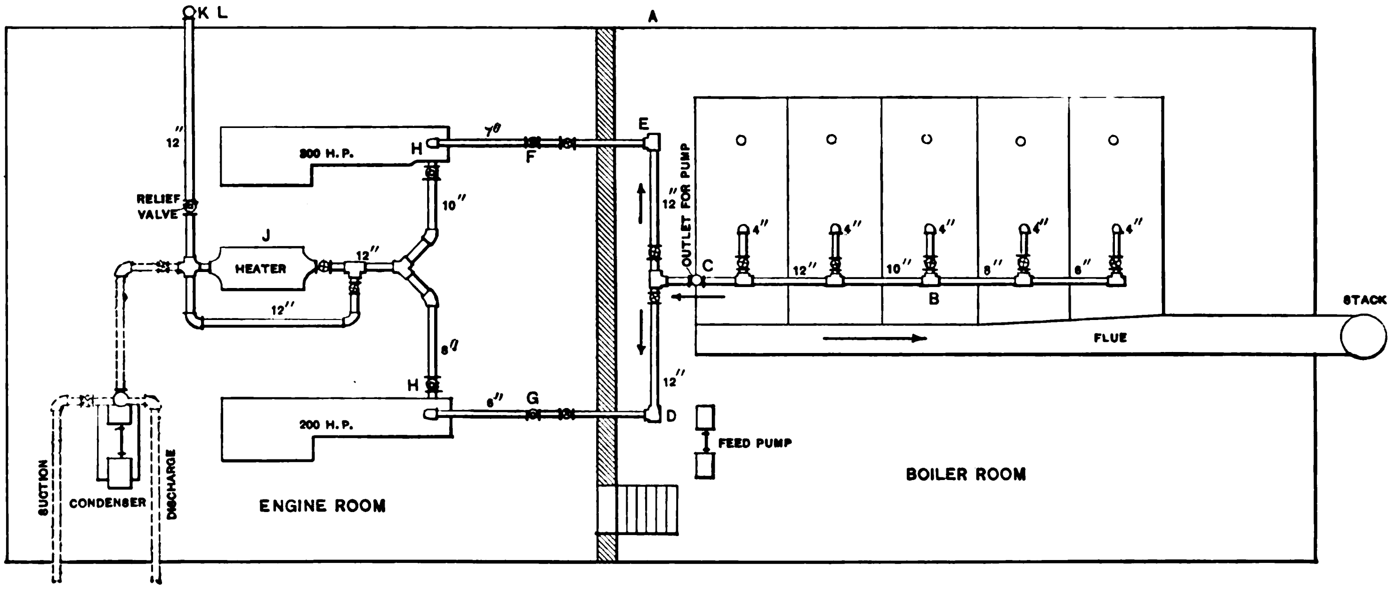
K L
A
12"
800 H.P.
H
10"
E
F
RELIEF VALVE
J
HEATER
12"
10"
12"
OUTLET FOR PUMP
12"
C
4"
4"
4"
4"
4"
12"
10"
8"
6"
B
STACK
FLUE
8"
H
200 H.P.
8"
G
12"
D
FEED PUMP
SUCTION
CONDENSER
DISCHARGE
ENGINE ROOM
BOILER ROOM

FIG. 5.—A 500-H.P. POWER STATION.

The suction pipe of the pump should be run from the nearest point of supply in the most direct manner possible. If the source is a pond or well outside the building, the pipe should be buried in the ground from 3 to 5 ft. deep, and a strainer should be placed at or near the suction end. This pipe should be galvanized, with galvanized fittings and screwed joints. Where there is more than one source of supply, each line of pipe must be provided with a gate valve.

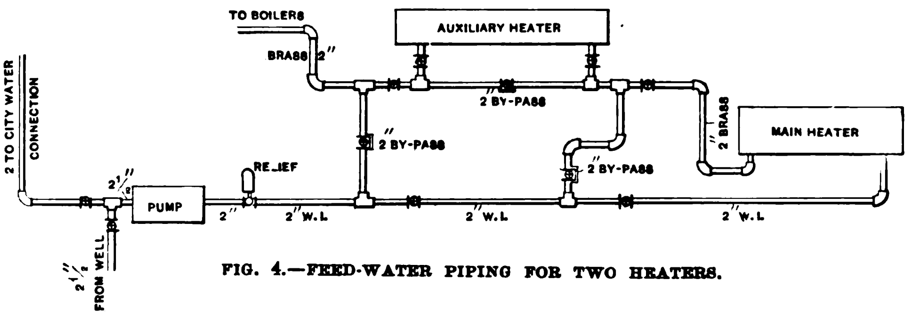
TO BOILERS
AUXILIARY HEATER
BRASS 2"
2" BY-PASS
2" BY-PASS
2" BY-PASS
2" BRASS
MAIN HEATER
2" TO CITY WATER CONNECTION
RELIEF
2½"
PUMP
2"
2" W.L
2" W.L
2" W.L
2½" FROM WELL

FIG. 4.—FEED-WATER PIPING FOR TWO HEATERS.

The pump discharge will be connected with the heater and also directly with the boiler, with iron pipe and screwed fittings. From the heater to the boilers the feed pipe will be brass, with brass fittings, valves and unions, all with screwed joints. A feed main should run across the front of the two boilers, to which the hot feed from the heater and the cold feed from the pump will be connected. Branches must run from this main to each of the boilers from Ts placed on the main. On each branch should be placed, in order, a union, check valve and globe valve. The arrangement of the water-feeding system is shown diagrammatically in Fig. 2. Where two heaters are in use, the pipes should be run as shown in Fig. 4. Water pipes are fixed in size by the pressure and quantity carried. Various empirical formulas are in use, and the old rule of thumb for high-pressure work is, a 1½-in. pipe for a 150-h.p. boiler.

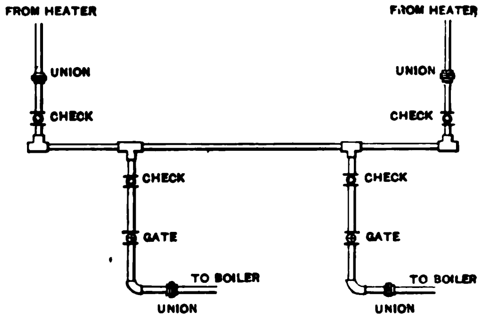
FROM HEATER
FROM HEATER
UNION
UNION
CHECK
CHECK
CHECK
CHECK
GATE
GATE
TO BOILER
TO BOILER
UNION
UNION

FIG. 3.—FEED-WATER PIPING FOR TWO HEATERS.

Certain pipe connections must be made for the boilers, as for instance, those in connection with the water columns, damper regulator and tube blower. A blow-off pipe must be run from the bottom of each rear end, a strong and durable valve or stop-cock being placed on each. The main blow-off pipe must run outside the building, or in city plants to a tank from which the condensation is carried to the sewer. A blow-off properly connected is illustrated in Fig. 7. All the main joints should be flanged and the material extra heavy.

There remains one important part of the piping of this small station to be considered, and this is the disposition of condensation. At all low points in the system condensed steam will lodge, and must be cared for. Starting from the boilers, the first low point is the under side of the 10-in. header. This being above the water line, the water can be returned to the boilers by gravity. The header should be tapped in the bottom of each outlet tee, and the outlets thus made connected with each boiler, a check valve and globe valve being placed on both boiler connections.

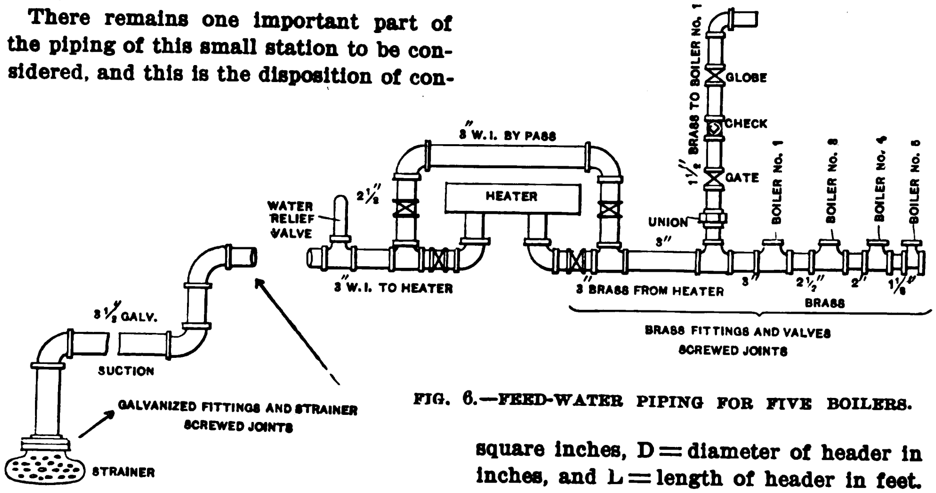

FIG. 6.—FEED-WATER PIPING FOR FIVE BOILERS.

In case the separator drip openings are also above the water line, they may be drained in the same way. If not, they should be piped to traps, as shown in Fig. 8. In a plant of this kind the traps would probably discharge into a drain pipe or blow-off tank. Various drip connections provided about the engines may be run direct to the main drain through valves.

On the exhaust piping, drip openings will have to be provided in the heater, at the foot of the riser, and from the exhaust head. If there is a surplus of exhaust steam, so that the heater outlets and the exhaust by-pass are smaller than the connecting exhaust main, the latter must be dripped as a "low point." All of the condensation from these points will contain oil, and is therefore probably unfit to return to the boilers. For this reason, what are known as "open heaters" are often used, such heaters being designed to extract all the oil from steam while heating the feed water. When they are employed, there are no copper coils to become coated with oil, and nearly every hot drip in the plant can be saved.

Drip pipes should be run individually, the result of uniting two pipes from sources differing even slightly in pressure being disastrous. Drains from pump pans, bearings, etc., which are of little value and are not under pressure, are carried to a main drain pipe (cast-iron soil pipe) buried in the floor and led out of the building.

There are no rules for the sizes of drip pipes. Common sense and intelligent figuring on the possibilities of the case will suggest what is required. For high-pressure steam headers draining by gravity, the writer uses the formula $D^2L \div 200 = d$, in which $d =$ drip area required, in square inches, $D =$ diameter of header in inches, and $L =$ length of header in feet.

Such a plant as we have described would probably be operated at a pressure not exceeding 100 lbs. Standard-weight pipes, fittings and valves would therefore be of sufficient strength for all parts. It will be found advantageous to place a little more weight in the header, to counteract the tendency to vibrate, and the four Ts there located may be made of the extra heavy patterns for this purpose.

PIPING FOR A 500-H.P. STATION.

Consider now a station located in the open country, and containing 500 horse-power in two simple units of 300 and 200 horse-power respectively. We will assume in this case that the line of boiler fronts is incorrectly placed; that is, at right angles with the crank shafts. The number of boilers is five, the pressure carried 125 lbs. The plant is to run non-condensing (Fig. 5).

The sizes of the engine supply pipes, determined by the method already explained, will be 7-in. for the large engine and 6-in. for the smaller one. The header is T-shaped, as shown in Fig. 5, so that it really becomes two headers, the end of the boiler header joining the engine header midway between ends. The boiler header may be tapered in size, each section being ample to pass all the steam that the boilers beyond it may supply. Following out this plan, the boiler header is shown as being made up on 12-in., 10-in., 8-in. and 6-in. pipe. The boiler pipes will figure out 4 in.; bent pipe will be used to carry steam from the boiler nozzles to the header, a valve being placed in each pipe near the header. The connections to the engines will also be of bent pipe, a quick-opening valve and separator being installed in each.

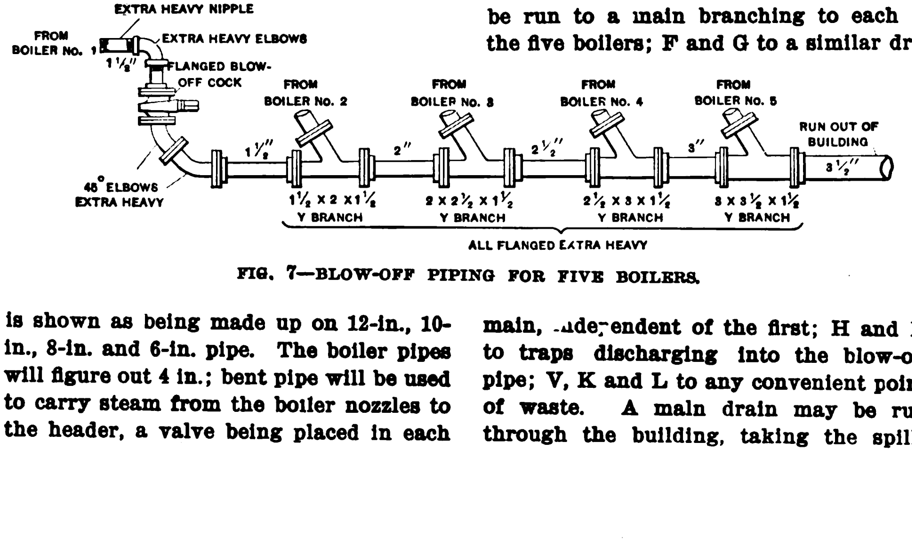

FIG. 7—BLOW-OFF PIPING FOR FIVE BOILERS.

The whole must be firmly anchored to the dividing wall and roof at the junction of the two headers, so that the expansion will be in the directions shown by the arrows. The short header should rest on roller brackets, the long one on roller hangers. Pipes, fittings and valves will be flanged, and standard-weight pipe, extra heavy fittings and heavy valves will be used. The 7-in. and 6-in. valves on the engine mains should be extra strong, quick-opening, with outside screw and yoke. The two 12-in. valves must have by-passes.

For exhaust steam, outlet pipes will run from the engines, through valves, to the proper level under the floor, and will then go through or around the feed-water heater and to the free exhaust riser and exhaust head. The riser should be of galvanized sheet-iron pipe; the remaining exhaust piping of cast or wrought iron, with flanged joints, fittings and valves. The pipes and heater must be supported by straps from the engine room floor beams.

The boiler feed and blow-off piping will be arranged as shown in Figs. 6 and 7. The steam-pipe for the pump and any other small apparatus will in this case be taken from the main header where indicated, as the expense of making connections to each of the five boilers for this purpose would be high. The pump exhaust may be carried independently to the point, A, in Fig. 5.

It is worth noting that the arrangement proposed is not the most economical possible. It would be better to install two heaters, one for each engine, and by running one engine at a little greater back-pressure, to heat the feed-water well above 200 deg. Such a system will be illustrated later, the intention being only to consider how to run the pipe for a given equipment, not how to plan the entire economizing system of the plant.

The points requiring drainage are indicated on the plan. These are, the bottoms of the Ts at B, C, D, and E; the separators at F and G; the small engine drips at H and H; the heater at V, the exhaust elbow at K, and the exhaust head at L. The drips from B, C, D and E will be run to a main branching to each of the five boilers; F and G to a similar drip main, independent of the first; H and H to traps discharging into the blow-off pipe; V, K and L to any convenient point of waste. A main drain may be run through the building, taking the spills from the two engines and pump, and discharging where desired.

To pipe this plant for the same engines running condensing, we must add the work shown by the dotted lines. The condenser being located as shown, a valved connection must be made to it from the main exhaust, and a relief valve must be placed in the exhaust pipe beyond the connection to the condenser. An injection pipe must be run from the pond or well to the condenser and supplied with a strainer at the pond and a valve at the condenser. This will be cast-iron with flanged joints. The discharge pipe from the condenser will be cast-iron with bell and spigot joints. Both these pipes will be run underground.

The steam and exhaust pipes for the condenser will run similarly to those used for the pump, but the latter may also branch to its own condensing chamber. A priming pipe, to introduce cold water into the condensing chamber if necessary, must be run from the main discharge pipe of the boiler feed pump.

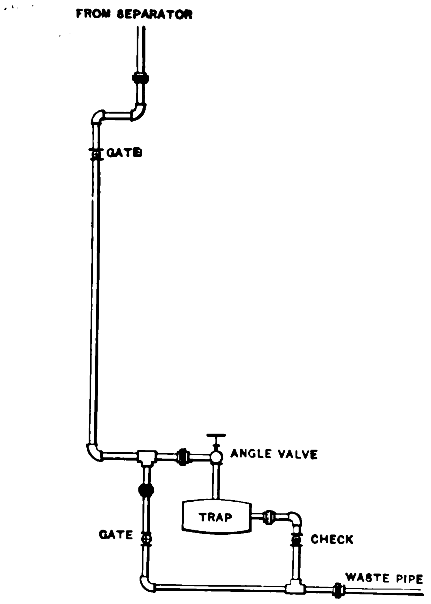

FIG. 8.—DRIP SYSTEM WITH TRAP.

◆

Licenses for Automobile Drivers in New York.—A bill has been introduced in the New York Legislature providing that all persons operating automobiles within the State limits shall be licensed by a local examining board, charged with the inspection of boilers and the passing upon qualifications of engineers. The board is expected to examine the persons applying for licenses and to inspect and test the motors. A fee of $1 is charged for examination and the license fee for each vehicle is $2. The proposed license will authorize its holder to run and operate the automobile through all public highways, streets and parks for a period of one year, but the examining board is empowered to revoke or suspend for a period of six months, any license upon satisfactory proof of drunkenness, incompetency or recklessness on the part of the holder.

A COMPARISON OF OPEN AND ENCLOSED ARC LAMPS FOR STREET LIGHTING.

BY H. H. WAIT.

A question confronting a great many central-station men at present is whether enclosed arc lamps are cheaper to operate than open arcs and whether enclosed lamps give satisfaction to both the opertor and the public. The following is a brief review of some of the principal points:

The enclosed lamp has practically driven the open arc from the field on constant-potential work, and for alternating circuits either constant-potential or constant-current open lamps are no longer considered.

The relative economy of series alternating-current systems, compared with direct-current series systems, is principally a question of whether the saving at the alternating station can make up for the lower economy of the alternating lamp. This is a distinct problem from the relative economy of the enclosed and open arc and was discussed at the American Institute Meeting of December 27th. (See American Electrician for January and Western Electrician of January 27, 1900, for discussion.)

In passing it might be remarked that the alternating systems seem to have the advantage where a small amount of arc lighting is to be done and that some form of direct-current system seems most advantageous where there is a large arc lighting load. In large alternating stations, and even direct-current stations, the series arc machines can be quite economically run by means of motors. This method of transforming the alternating power into constant direct current affords a means of readily comparing the economy of open and enclosed lamps when the problem involves an alternating station.

When operative series-alternating systems were first introduced they filled a long-felt want and the tendency was to introduce them even under conditions where they were not the most economical system. Station men are now investigating the problem more carefully, so that there are not so many plants being disadvantageously installed.

The primary consideration in installing a new system is whether it is sure to work. As far as the enclosed lamps themselves are concerned, direct-current enclosed lamps have been in general successful use for over two years. The only liability to danger in this respect is in trying new mechanisms out of the well-recognized path.

Alternating-current lamps will probably always give a little more trouble than direct-current lamps on account of the somewhat less substantial character of the mechanism and on account of the vibrations to which the mechanism is subjected. The older forms of alternating-current enclosed lamps were quite frequent visitors to the overhauling department, but several years of experience have enabled the manufacturers to produce lamps that will stay out without much more attention than direct-current lamps. Attempts to simplify the mechanism in order to get unusually high efficiencies have generally resulted in very annoying failures in practical operation.

There is no question about the operativeness of the generators for either direct or alternating systems. Arc generators running at six or seven amperes are an old story and it is only when unusual sizes are contemplated that any doubt need arise on their account.

Constant-direct-current enclosed lamps taking 450 watts have been run in practice at 6 amperes and 75 volts as the usual extreme in one direction, and 7 amperes and 65 volts as the other extreme. There is no practical difference in the life of the carbons between these extremes and good lamps operate quite satisfactorily between these limits. The 75-volt arc is, of course, longer and the light emitted is distinctly more violet. The arc "wanders" noticeably more than with the higher current and the carbons burn with flatter tips. Below 64 volts the arc becomes variable, corresponding to the hissing point in the open arc. For this reason it is well not to attempt to run too close to this limit unless care is to be taken to keep the lamps accurately adjusted. Where a 7-ampere current is used there is, of course, more danger of burning out small enclosing globes due to bad adjustment of the lamps. For series work there is not the same incentive to keep the voltage up as in constant-potential work, so that lamps at 80 volts and 5.6 amperes have a great many disadvantages.

It is probable that practice will settle down to a rating of about 6.8 amperes and 67 volts. The higher current does not involve a corresponding loss in a great many cases because 10-ampere circuits are already in place and in new plants the wire cannot be decreased in size very materially in new plants without resorting to the use of hard-drawn copper.

At 67 volts per lamp, 125 lamps would require 8400 volts; 8000-volt circuits are in common successful use and higher voltages are used occasionally on series arc circuits. It will be seen, however, that circuits containing over 125 of these lamps are a step in advance of the common practice. The past leads us to expect a gradual extension in this direction as the accompaniment of the improvement in the construction of the generators and line material.

If it is desired to run a larger number of lights from a single machine and not go beyond the limits of established practice, resort must be had to multi-circuit dynamos. There are two types of these machines, those in which the circuits are joined in series (Brush) and those in which the circuits are in parallel (Western Electric). Both of these types have been in use several years and operate successfully in every-day work. It is only in units of over 200 lights that new problems need be expected to present themselves.

With the series alternating systems several forms of current-regulating mechanisms have been in successful use for some time, so that no uncertainty need be apprehended from this source unless new types of mechanism are contemplated. I cannot close this question of operativeness without paying a tribute to the old open arc lamp. There are probably few such complicated mechanisms in the service of man which have to perform their work day after day under such adverse circumstances and which stand up so well under abuse and accompanying malignment.

The relative illuminating value of different arc lamps is one of the most difficult problems connected with electric lighting. The principal factor in the problem is the intensity of the light as measured in candle-power. The other factors of quality, distribution and steadiness are as difficult to determine accurately as the intensity. They all depend more or less upon the photometer. The same lamp measured with different instruments by different observers will give curves which differ by very large percentages, so that the only safe way to draw any general conclusions is to make use of the averages of the results of different experimenters. Unsatisfactory as are photometric tests, there does not seem to be any better way of approaching the problem.

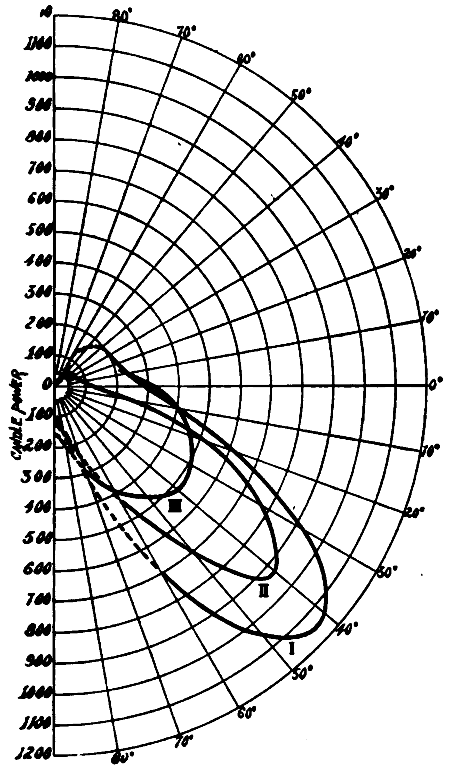

FIG. 1.—CANDLE-POWER CURVES.

The accompanying curves are made up by taking the average of curves published by Marks, Matthews, Thompson and Hilbish, curves made in the General Electric Company's and the Western Electric Company's laboratories, and some older curves on open arcs.

Fig. 1 gives the intensity of light in candle-power of three different types of direct-current lamps. Fig. 2 gives some curves from alternating lamps with Curve III of the direct-current lamps superimposed for the sake of comparison. Curve V is the average of three different curves of alternating lamps with opalescent globes and without reflectors. This curve is put in to show the general shape of the field of light from the alternating arc. Its intensity and efficiency are not comparable with the other curves, as two of the lamps were run at lower wattage than 450.

DATA RELATING TO TESTS.

	Watts at arc.	Watts per mean spherical c.p.	Watts per mean hemispherical c.p.
1—Direct-current open arc....	450	1.2	.8
2—Direct-current enclosed arc clear inner globe..............	450	1.8	1.0
3—Direct-current enclosed arc alabaster inner globe with reflector	450		. 1.2
4—Alternating-current arc alabaster inner globe with reflector	450		1.6
5—Alternating-current enclosed arc opalescent inner globe without reflector...............	...	...	...

The curves from which these curves were averaged differ considerably among themselves, especially in lamps having opalescent globes where the figures vary as much as 3 to 1. The efficiencies given by various authorities differ quite as widely as the curves, varying all the way from .85 to 5 watts per mean hemispherical candle-power for an enclosed direct-current lamp stated to have thin opal or alabaster globes. Where the question of the absorption of the globe is eliminated the results of different experimenters agree sufficiently to give reasonably sure averages. The absorption of clear inner globes when clean is variously stated from 1½ to 12 per cent., that of alabaster globes from 5 to 20 per cent., and that of opal globes from 45 to 65 per cent. The absorptive power of the coating of the globe at the end of the run may be anywhere from zero to 30 per cent. Where the deposit on the globe is a clear, flaky white the intensity of light is even increased in certain directions by the reflection from this surface. In good direct-current lamps with solid carbons and large globes the deposit is hardly sufficient to reduce the light within the limits of casual observation. Alternating-current lamps have a greater deposit on account of the cored carbons and on account of the customary practice of running them at a higher wattage.

Fig. 3 shows the intensity of illumination at the street surface computed from Curves I, II, III and IV. In computing these curves the intensity at a given angle is read off of the polar curve of candle-powers and divided by the square of the distance from the lamp to the corresponding point on the street. This gives the intensity of illumination on a plane normal to the ray of light at that point. The resulting values are plotted in Curves I, II, III and IV below the base line, the depth of the curve at any point representing the intensity of illumination in candle-feet at this point. The intensity in candle-feet necessary to read is about one, representing the intensity of light from one candle at one foot. A reasonable mean intensity for street illumination would be about one-tenth of this value. For the purpose of illuminating the streets for passers-by a minimum of even less than this might be considered quite reasonable.

The main fact is that the public acquiesces in the substitution of 450-watt enclosed direct-current lamps in place of open arcs. The intensity of the light is not noticeably less and the steadiness and distribution are somewhat better. The kicks against such substitution are perhaps only frequent enough to be the exceptions which prove the rule, and these, when traced down, appear to arise more from an unsuitable location of the lamps or from a desire to take advantage of a change to get lower rates than from any deficiency in the lamps. The objection hardest to overcome is the violet color of enclosed arcs for certain classes of interior lighting. With alternating-current lamps the difference in light for the same wattage is quite appreciable to the public and the violet color is more noticeable than in the direct-current lamps.

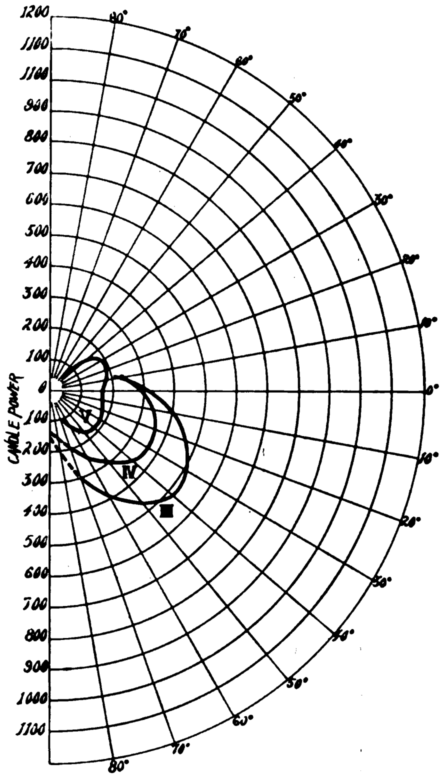

FIG. 2.—CANDLE-POWER CURVES.

The principal danger to stations installing either of the enclosed types of lamps is from the competition of old or new companies operating open lamps, who can readily make photometric demonstrations of the greater intensity of their lamps, thereby causing at least considerable annoyance to the users of enclosed lamps.

It will be seen that the principal advantages in regard to distribution in the enclosed arcs are due to the use of alabaster or opalescent globes and to reflectors. It is quite likely that equally good distribution can be obtained by the use of opal globes on open arcs, provided they are arranged to suit the conditions. With holophane globes and focusing lamps the light can be thrown almost anywhere it is desired.

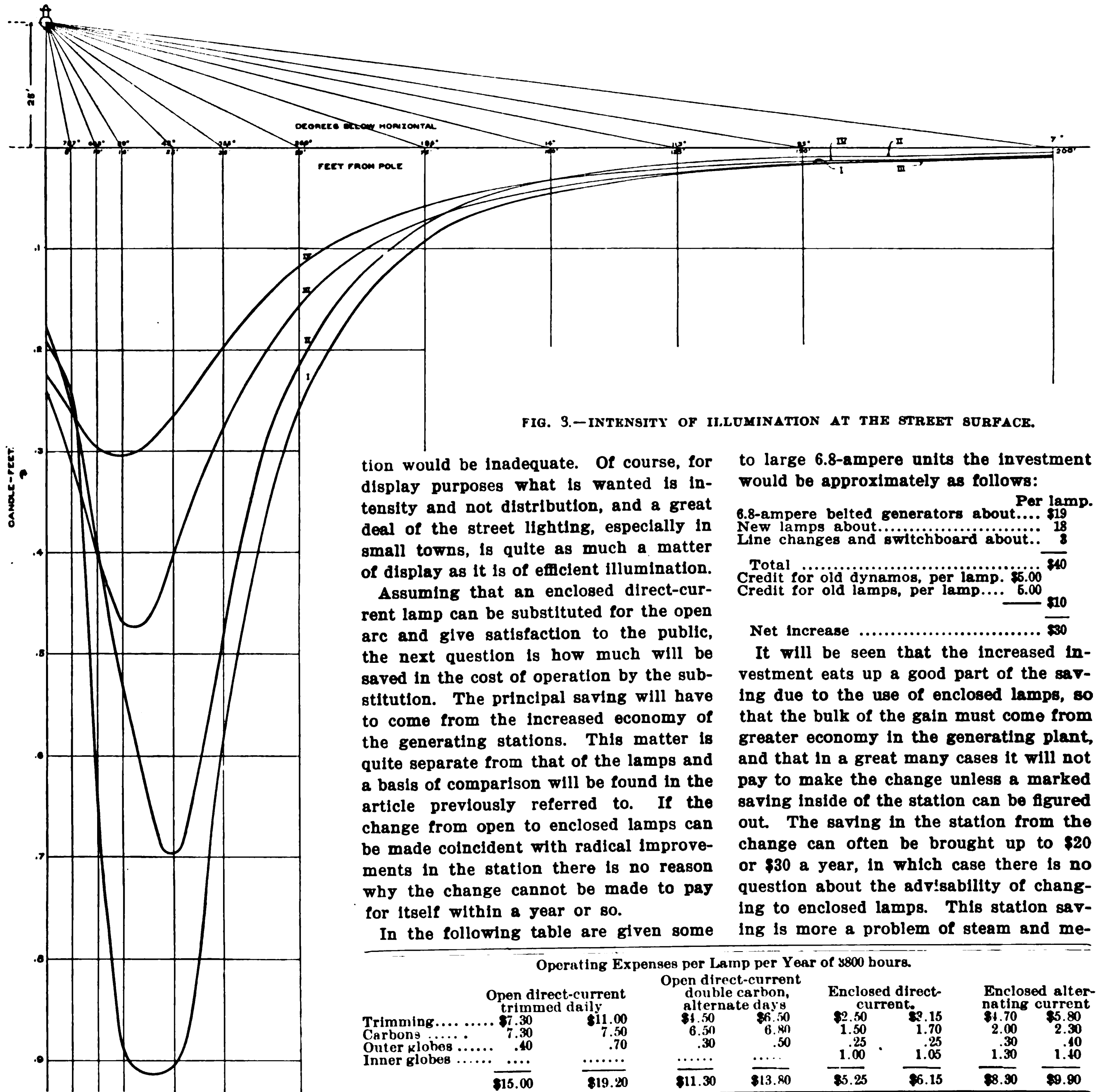

FIG. 3.—INTENSITY OF ILLUMINATION AT THE STREET SURFACE.

It is a question whether a fixed minimum intensity of illumination is a desirable thing. In districts of large areas it is so much cheaper to maintain a specified minimum illumination by means of incandescent lamps or Welsbach lights that arc lamps are practically out of the question if lighting is to be specified in this way only. Of course, if the minimum is a very high value this would not be the case, and at this extreme no method could compete with open arcs placed close together. It is probable that a light which gives quite brilliant zones and quite dark ones is just as serviceable as a light of the same mean value but of more equal distribution. The brilliantly illuminated regions serve as a background for objects in the dark regions and the passer-by can make use of the strong light in the bright zones for a number of purposes for which the maximum of the more even distribution would be inadequate. Of course, for display purposes what is wanted is intensity and not distribution, and a great deal of the street lighting, especially in small towns, is quite as much a matter of display as it is of efficient illumination.

Assuming that an enclosed direct-current lamp can be substituted for the open arc and give satisfaction to the public, the next question is how much will be saved in the cost of operation by the substitution. The principal saving will have to come from the increased economy of the generating stations. This matter is quite separate from that of the lamps and a basis of comparison will be found in the article previously referred to. If the change from open to enclosed lamps can be made coincident with radical improvements in the station there is no reason why the change cannot be made to pay for itself within a year or so.

In the following table are given some figures on the relative operating expenses of the lamps themselves.

Operating Expenses per Lamp per Year of 3800 hours.

	Open direct-current trimmed daily		Open direct-current double carbon, alternate days		Enclosed direct-current.		Enclosed alternating current	
Trimming	$7.30	$11.00	$4.50	$6.50	$2.50	$3.15	$4.70	$5.80
Carbons	7.30	7.50	6.50	6.80	1.50	1.70	2.00	2.30
Outer globes	.40	.70	.30	.50	.25	.25	.30	.40
Inner globes	....	....	......	.....	1.00	1.05	1.30	1.40
	$15.00	$19.20	$11.30	$13.80	$5.25	$6.15	$8.30	$9.90

The first column for each lamp is what might be considered a low average value for first-class service. The figures in the second column in each case are the same as those in the paper on the cost of arc lighting and will represent an average cost where wages and other expenses are higher. An inspection of this table will show that the encased lamp in itself will save something less than $10 per lamp per year for all night running and that this difference would decrease with shorter hours and also with lower candle-powers.

This saving is a clear gain if the installation is a new one. With an old plant it will be necessary to increase the investment to effect this saving. For example, in changing from a number of comparatively small 10-ampere machines to large 6.8-ampere units the investment would be approximately as follows:

		Per lamp.
6.8-ampere belted generators about		$19
New lamps about		18
Line changes and switchboard about		3
Total		$40
Credit for old dynamos, per lamp	$5.00	
Credit for old lamps, per lamp	5.00	
		$10
Net increase		$30

It will be seen that the increased investment eats up a good part of the saving due to the use of enclosed lamps, so that the bulk of the gain must come from greater economy in the generating plant, and that in a great many cases it will not pay to make the change unless a marked saving inside of the station can be figured out. The saving in the station from the change can often be brought up to $20 or $30 a year, in which case there is no question about the advisability of changing to enclosed lamps. This station saving is more a problem of steam and mechanical engineering than electrical engineering.

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A Municipal Telephone Exchange—The San Francisco Board of Supervisors has decided to issue an immediate call for a complete municipal telephone exchange having a capacity of from 18,000 to 25,000 subscribers.

ELECTRICAL EQUIPMENT FOR SMALL CENTRAL STATIONS

BY L. B. MATHER.

Starting with the smallest usual type of central station—a three-wire incandescent system—one is confronted at the outset with the necessity for deciding between two dynamos of equal output and a single dynamo of the voltage required across outside wires together with a balancing outfit of some sort. In very small plants the preference would probably be for the two identical dynamos, but as soon as the output of the station reaches anything like a respectable size, say 100 h.p., a maximum voltage dynamo with a motor balancer is by far preferable; such an arrangement is shown diagrammatically in Fig. 1.

It is common practice in England to accomplish the balancing of the two sides of such a system by means of either a dynamotor or an engine-driven balancer consisting of two half-voltage dynamos driven by a single engine. The two commutators of the dynamotor are connected up exactly like the two separate armatures of the motor-balancer represented by Fig. 1. The engine-driven balancer operates exactly like the two dynamos of the old Edison system, except that the capacity of each need be equal only to the maximum difference between the two loads of the system. Of the two methods the engine-driven balancer gives the more satisfactory result, but it possesses the disadvantage of requiring manipulation and also is expensive to install, compared with the arrangement indicated by Fig. 1 or the corresponding dynamotor balancer. Either the engine-driven or the dynamotor balancer is better than the division of the generators into half-voltage units of equal output, and the motor-balancer with exchanged field windings, indicated by Fig. 1, is best yet.

It is true that in the two-dynamo arrangement (Edison) there is the advantage that in the event of accident to one of the dynamos one-half of the total output remains available, but if the dynamos are properly built and handled the liability to disablement is remote and can be provided against by the maintenance of spare dynamo parts. The motor-balanced system has the advantage of better efficiency in the main generating apparatus and also fewer parts that are particularly needful of attention. The small output of the motor-balancer renders its operation most reliable, and the repairs to such an equipment are much less frequent and expensive than those required by a dynamo of one-half the total output. All things considered, it is considerably easier to maintain continuous service with one 100-kw. dynamo and a motor-balancer of say 15 kilowatts output per machine than it is with two 50-kw. dynamos, provided, as already remarked, proper precautions are observed in the way of keeping on hand spare parts. Under such conditions a plant having no day load has not the slightest excuse for failing in its performance at night. A plant running night and day should, of course, have duplicate generating sets throughout: engines, dynamos and balancers.

An admirable arrangement for plants of moderate size supplying a day load is to provide a battery of accumulators of sufficient capacity to take something more than the peak of the load. Then the generating plant should be of sufficient ability to handle the maximum load at a pinch, in case the battery should meet with disaster, athough disasters of such magnitude as to render an accumulator equipment unavailable are extremely rare. A combination of accumulators and generating plant of this kind gives a beautifully flexible station equipment, besides enabling one to carry out some economy in the matter of labor. The generator runs all day, from the usual starting hour of industrial establishments that might be taking motor service, and the accumulators are charging up to the time when the peak of the load begins to appear, when they assist the generating plant in maintaining the load. During the period between the fall of the load curve to its normal value and the point where it assumed its minimum rate, the battery could maintain the entire load, allowing the steam and dynamo plants to be shut down, and reducing the working force to two shifts of reasonable duration each. Moreover, if a battery be used, it will not be imperative to have two full capacity generating units, although this is always preferable for 24-hour plants. Without the battery two full capacity generating equipments are absolutely indispensable for day and night service.

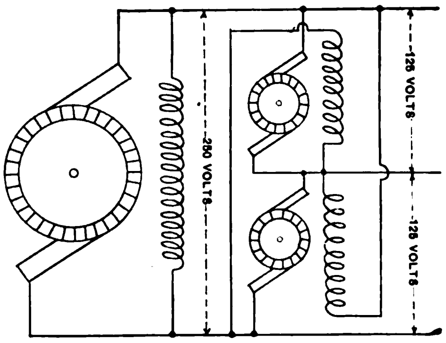

FIG. 1.—MOTOR BALANCER.

The capacity of the motors constituting the balancer in such a plant is determined, of course, by the degree of electrical balance obtainable on the distributing lines. A well-designed distribution system should not ever have more than 20 per cent discrepancy between the two loads on each side of the neutral wire; in such a case, each of the motors should have an output of about one-tenth that of the main dynamo. The capacity of the accumulator battery will depend upon the character of the load peak and the elapsed time between the point where the load goes beyond the comfortable output of the dynamo and the point where it comes back to that value. It is commendable to provide a battery the 10-hour discharge rate of which is about equivalent to the difference between the dynamos and output and the maximum of the peak. This will allow a goodly margin for other purposes, such as shutting down the steam plant during the periods of lightest load. The duration of the peak, so to speak, is seldom over five hours, even where some of the consumers are on flat rates, and where meter service is rendered, the battery should be required to assist the dynamo not more than four hours, and usually three will cover the period. This leaves a substantial margin of battery capacity which will even permit a steam shut-down of a few minutes under ordinary night load for the correction of some subordinate trouble. It will be obvious that where a battery is installed the motor-balancer is not strictly necessary, as the battery will serve to maintain the proper division of voltage at the bus-bars. It is better practice, however, to install at least one balancing set so as to be independent of the battery.

Where the distribution is compact, the simple arrangement above outlined is efficient for all three of the usual classes of service: arc lamps, incandescent lamps and motors. The motors will, of course, be connected up to the outer wires of the system, and it would be preferable so to connect the arc lamps (in multiple series) if lamps are available that will regulate satisfactorily in series on a constant-potential circuit. This will admit of the use of three enclosed arcs or five open arcs in each series group.

For plants in which there is some scattered distribution (still considering a very small plant) it will be advantageous in many instances to run only the outer wires to remote points, employing high-voltage incandescent lamps there. Wherever all three wires can be economically extended, it will be preferable to use the ordinary 110-125 volt lamps. The high-voltage lamps should invariably be supplied through meters; indeed, it is infinitely preferable to supply all service on this basis, but particularly so in the cases where high-voltage service is rendered. Where the scattered load constitutes the bulk of the output it will be usually advisable to employ 500-volt generators and a five-wire distributing system for the incandescent lamps, using either four motors, coupled like the two in Fig. 1, or a storage battery for balancing the divisions of the system, or a combination of the two. The remarks relating to the 250-volt system also apply to this.

For a small plant in a locality where the distribution is mostly scattering, but where the motor load is comparatively unimportant or of a character easily taken care of by means of induction motors, the very best plan is to use two-phase alternating-current generators and distribution, at 60 cycles frequency. The generating units should not be smaller than 100 kilowatts output, and if there be a day load there should not be fewer than two units, no matter how small the plant may be. It is preferable, with due regard for the total output of the plant and the minimum limit of size above advised, to divide the generating plant into three or four units, the aggregate capacity of which shall be somewhat above the immediate output in order to allow extensions of service to a reasonable extent without necessitating additional station equipment.

For example, a station having a maximum output of any value between 100 and 175 kilowatts would advisedly contain two units of 100 kw. capacity each; one of 200 to 250 kilowatts output might contain either two 150-kw. or three 100-kw. units, preferably the latter; one of 300 to 350 kilowatts output would preferably contain four 100-kw. units, and so on. Up to the point where the units attain uncommercial sizes, four or five units present the maximum of combined efficiency and flexibility; the sizes should be so chosen that if one unit becomes disabled the others can carry the maximum load of the station without risk. Such a division of the generating plant would allow all of the units to be shut down during the periods of lightest load, and the plant could be run always around economical load. These remarks apply more especially to alternating-current generators because a storage battery cannot be employed in combination with them to equalize the load and provide a reserve.

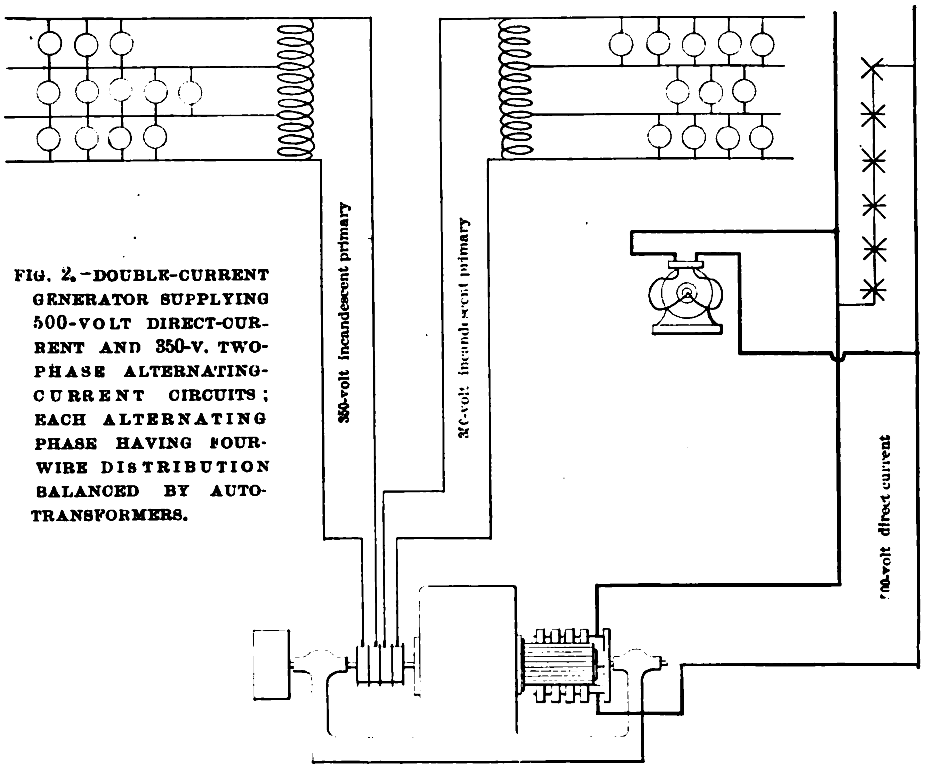

FIG. 2.—DOUBLE-CURRENT GENERATOR SUPPLYING 500-VOLT DIRECT-CURRENT AND 350-V. TWO-PHASE ALTERNATING-CURRENT CIRCUITS; EACH ALTERNATING PHASE HAVING FOUR-WIRE DISTRIBUTION BALANCED BY AUTO-TRANSFORMERS.

For small plants in which the arc lighting and motor loads, either singly or in combination, constitute the most important feature of the station output, a compromise between the two plans just outlined would doubtless be most satisfying as to all-round considerations. That is to say, the use of double-current generators giving 500-volt direct current at one side, for the motor and arc lighting circuits, and two-phase alternating currents at the other side for the incandescent service. It is not necessary to use special double-current machines, as the generators for plants of the class under consideration would naturally be belt-driven and an ordinary railway generator having a "stiff" field would serve admirably by adding collector rings at the back end of the armature and driving the machine at such a speed as to obtain about 25 cycles at the alternating-current side.

The alternating-current brushes would deliver about 350 volts, which could be changed to the proper lamp voltage at various distributing points either by means of transformers or by auto-transformers which would have four-wire distributing circuits led out from them, as indicated by Fig. 2. The e.m.f. between wires would be about 110 volts, the common standard. This system possesses the advantage over the purely alternating-current system of allowing the use of storage batteries, as outlined in the plan first discussed. These would be connected across the 500-volt direct-current busbars, of course, and they could take care of the peak of the load, as in the first plan, regardless of which one of the circuits is mostly responsible for the peak. If the peak is all on the alternating-current side (which will very rarely be possible) the battery can take care of all of the direct-current load, and if it should be necessary, feed the alternating-current lines through the armature of the generator, which will act as a reversed rectifier, or inverted rotary converter. Even if a battery be used, however, two generating units must be provided in order to maintain reliable service, and it would be preferable to have three, if the plant is large enough to justify three 100-kw. machines, as the alternating-current load is entirely dependent upon the generating plant.

The obvious objection to this plan is that one of two evils must be shouldered: 25-cycle transformers wound for a ratio of 350 to 110, or auto-transformers and a double four-wire secondary system. If ordinary transformers be used with such a system they will probably have to have special windings. By employing step-up transformers in the station the line potential may, of course, be made standard, and this has been recommended by some engineers. To the present writer such a course appears highly unpractical for plants of the class under discussion, as it involves double transformation of the entire alternating-current output of the station and the expense of station transformers equal in output to the generator. This, in fact, would be very little better, if any, than the use of two generators for the two classes of service.

The secondary distribution circuits of a system such as the one last described would be difficult to keep in balance, and serious lack of balance between the two phases would affect commutation on the direct-current side of the generators, probably perniciously. For these reasons the plan is commendable solely and only for small plants in which the incandescent service is of some importance and its distribution very scattered. Under other conditions the two plans previously described are greatly preferable to this one: the three-wire or five-wire direct-current where an all-round service must be maintained and the distribution area is partly or chiefly scattering, and the wholly alternating-current system where the motors and arc lamps of a scattered distribution are relatively unimportant.

HOT-WATER HEATING FOR CENTRAL STATIONS.*

BY H. T. YARYAN.

It does not require the eye of a prophet to foresee the future means of heating and lighting our cities. If heat, using water as a vehicle, can be distributed from a central station covering a territory measured by a radius of one and a half miles from the station, and do it with profit to the investors and entire satisfaction to the consumers, the problem would seem to have been solved. This has been done by the Toledo Heating and Lighting Company for the past five years, a period sufficiently long to place the enterprise beyond the experimental stage, and entitles it to be classed as a successful business venture.

I think it will be found that when the new system is generally introduced, in connection with the production of electricity, you will be forced to modify your views on high-pressure steam and the compounding of engines. Where steam economies are of little avail seven months out of the twelve, and where seven months cover four-fifths of the electric output for the year, there would seem to be little encouragement for heavy outlay in that direction. Fortunately for the system the demands for heat and electricity run almost on parallel lines a large portion of the year.

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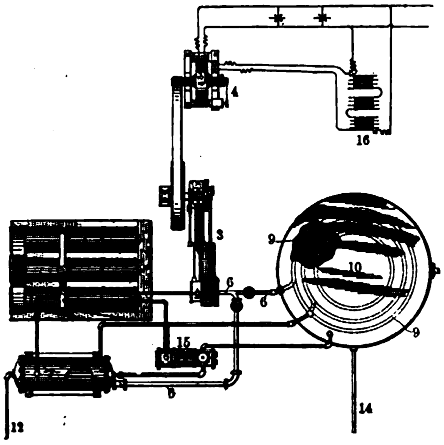
*Abstract of a paper read before the Cincinnati meeting of the American Society of Mechanical Engineers, May, 1900.

Under the new system electricity becomes a by-product, the only cost of fuel being the condensation of engines, which will average probably 20 per cent. here. Experience has shown that for every dwelling house heated, it requires the exhaust from engines necessary to light four. It therefore follows that the lighting district must be extended beyond the heating, or some other use be found for the output, such as street railroads, if the entire city is to be heated. If some great genius, like an Edison or a Tesla, were to announce to this society that electricity could be produced without cost, I imagine there would be a sensation; and yet the Toledo Heating and Lighting Company is doing this very thing, as the six months' business ending January 1 last shows, the load being 199 houses heated and 450 lighted.



6.—Exhaust pipes. 10.—Hot storage.
7.—Heater. 12.—Delivery pipe.
14.—Return pipe.

FIG 1.

Receipts from heating		$9,900.98
Receipts from lighting		9,064.78
Fuel	$5,040.63	
Wages and salary	2,827.63	
Expense (taxes, repairs, oil waste, etc.)	1,896.77	
	$9,764.54	

I presume the question will be asked why electricity should be treated as a by-product instead of the heat. My answer is that charges for heat can be fixed and maintained, the consumption of coal increasing proportionately with the number of consumers, while the opposite is true of electricity, and a flexible scale of charges is necessary if the large excess of output is to be disposed of.

Most of you will recollect the disastrous failure in Boston, about twelve years ago, in an attempt to distribute hot water from a central station. A large sum was invested, and the work of installation was of the highest order. I have no direct information as to the causes of this failure, but it is not hard to figure out if one reads the paper of Chief Engineer Abbot before the Boston Society of Civil Engineers. The two mains laid were 4 in. for outflow of hot water, and 6 ins. for return. The proposition was to heat water to a temperature of 400 deg., F., and to circulate, necessarily, under a pressure of 250 pounds. He says in his paper, that the maximum rate of circulation would be from 10 to 15 ft. per second. If I can figure friction, and making a liberal allowance for the less viscosity of hot water, there would be lost in pressure from 3½ to 8 pounds per 100 ft., or at the end of a pipe 3,000 ft. from the station, from 100 to 240 pounds.

The effect of this on super-heated water would be to convert a large portion of it into steam, and the small service pipes of ¼ to ⅝-in. diameter to the various houses would not deliver a sufficiency of the mixed steam and water to heat the buildings. Other troubles would follow in the return pipe. There are many other troubles which they must have encountered that I could mention, but the one given is sufficient, as it was inherent and fatal to the working of such a system.

The system I am about to describe, and shown by Fig. 1, is so simple that but few words are necessary to make it intelligible. The steam boilers, engines and dynamos are such as may be used in the ordinary electric-light station. Heaters of the tubular type, through which the water passes from the pumps to the mains, receive the exhaust steam from the engines, heating the water to any desired temperature. When more exhaust is being produced than is required to heat the water, the excess is delivered to a water-storage tank to be used later, when the output of electricity is small. The circulating system consists of two wrought-iron pipes, laid side by side in the ground, carefully protected by insulation, one pipe for the outflow of hot water impelled by the pumps, the other for the return water from the coils in the various houses heated, going back to the suction end of the pumps, to be forced again through the heaters, where the loss in temperature is restored.

The Toledo Heating and Lighting Company has two stations, known as the Floyd Street and the Twenty-second Street stations, and although the heating mains of the two stations are separate and distinct, the dynamos of the two stations feed into a common system of electric mains. The length of the double water mains connected to the Floyd Street station is 8560 ft., and the number of houses heated is 101. The length of mains from Twenty-second Street station is 8260 ft., and the number of houses heated is 98. The amount of radiating surface connected with the Floyd Street station is about 90,000 square feet, and that connected with the Twenty-second Street station about 85,000 square feet. The amount of coal consumed at both stations during the heating season, from October 1 to May 1, averaging 5000 short tons of coarse slack, or about 25 tons to the residence.

These same buildings, if heated by their own furnaces, would average not more than 18 tons of hard coal each. The difference may be accounted for by the loss of heat in ground radiation, and largely by the fact that we heat the buildings more thoroughly and for a greater number of hours than they could or would do by private furnaces. The loss of heat through radiation in our mains is an important one, and I am sorry not to be able to give positive data, but it is impossible to do more than approximate the loss. From careful observation, I estimate the loss to be between 15 and 20 per cent. The water reaches the extreme end of our lines, three-quarters of a mile from the station, in the coldest weather, with a loss of 12 deg. F., which would be an average of 6 degs. to all of the houses. As the water return to the station with a drop of 35 degs., this would indicate about 17 per cent. loss in the ground, which I believe to be nearly correct.

A pressure of 60 pounds is maintained on the feed line during cold weather, and 40 pounds during moderate weather. The service pipes to the various houses are 1-in. pipe, and the return line throttled with disc inside the building, the size of opening depending upon the quantity of radiation, but average ⅝ of an inch. The houses are equipped with radiation sufficient to heat them to a temperature of 70 deg. F., with water entering the house at 160 deg. F., when the outside temperature is freezing. By raising or lowering the temperature of water one degree for each degree of variation in the outside temperature, we are able to maintain a constant temperature in the houses during all kinds of weather. There is no occasion for the consumer to regulate the flow of water during the entire winter, and with few exceptions our consumers open the supply valves in the fall and only close them in the spring. The extreme limits of temperature of the water is from 130 deg. in moderate weather to 212 deg. in the coldest.

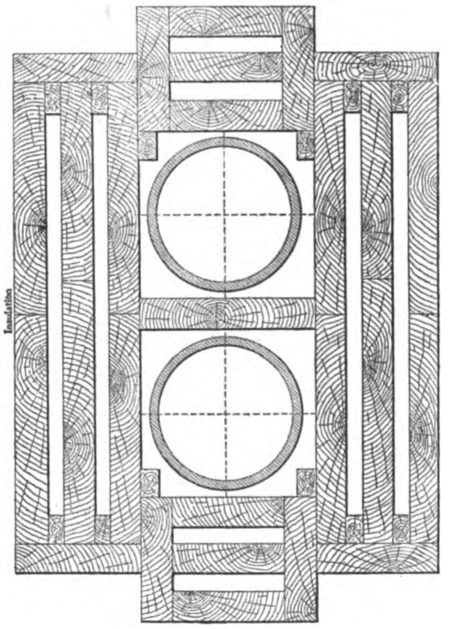


FIG. 2—PIPE INSULATION.

The insulation used is shown in section by Fig. 2, and is both effective and inexpensive. The top, bottom, and sides are made in separate sections by using for top and bottom three 1-in. boards, separated with ½-in. strips to form air spaces, with 1-in. by 4-in. boards on the sides to prevent the entrance of earth. This manner of insulation is as near perfect as can be hoped for, and the only improvement which might be suggested is to cresote the outside boards. After four years of use, the only sign of rotting is in the outside boards which come in contact with the earth. The heat in the mains keep all other boards perfectly dry, and it would seem that their life was indefinite. The mains are laid in a ditch only 30 ins. deep, as we have found by experience that the nearer they are to the surface of ground the less loss by radiation. The reason for this is simple enough, as wet ground is a better conductor of heat than dry, and the deeper you go the longer the ground remains wet.

The heaters are really surface condensers, and I have some hundreds in use for this purpose, the only novelty about them being the manner of providing for the difference in expansion of copper tubes and iron shell. No thimbles or other devices are used to permit a slip through flue sheets, but each tube is rigidly expanded in the top and bottom flue sheet. They are 7 ft. long, 24 ins. in diameter, and contain 500 ⅝-in. copper tubes. The tube before entering is bent so as to make a permanent sag of ⅝ in., which is intensified to about ¾ in. in expanding, by the use of a drift.

As all the water of condensation is sent back to the boilers, a thorough separation of oil is necessary. I have found most of the so-called traps a delusion, as they depend upon slowing down the steam current to permit the particles of oil to be dropped. The finer particles, however, are so thoroughly entertained that they are carried to the condensers and thence to the boilers. The trap shown by Fig. 3 was really constructed to separate entrained salt water, in distillers on shipboard under a vacuum, where the speed of vapor is high. The principle involved is separating the volume of vapor into jets by passing it through 1-in. tubes equal in area to the exhaust pipe, so that only a narrow space intervenes between the end of tube and the impinging surface.

The very smallest particle of entrained substance is carried over this space by its own momentum, and is held by the impinging surface, whence it runs off through the drain pipe. Incidentally, I may state that fully one-half of the oil used on the engines and pumps is recovered and used over again.

The provision for expansion on underground mains is of vital importance. After trying all manner of devices, the ordinary U-bend, where the run is straight, and 90-degree bends at corners, answer the purpose admirably and give no trouble whatever. The U-bends are placed about 600 ft. apart, and as the extreme expansion is about ¾ in. to 100 ft., only 4½ ins. are necessary to be taken care of by each U-bend. As the mains are laid cold, we put an extra strain when laying on the U-bends in an opposite direction to that in which they work when allowing for expansion.

Almost the first question asked by a practical engineer is, "How about the corrosion of your pipes?" I am happy to say that I can answer this question in a satisfactory manner, as over 10,000 ft. of pipe were relaid last summer, after being in use five years. The wrought-iron pipe showed no signs whatever of corrosion, but steel pipe was perceptibly affected. There was a great difference in different lengths of steel pipe, but all were affected more or less. The appearance of the pipe showed the formation of nodules on the inside, varying in number from one dozen to 100 in a length of pipe, and in size from a grain of corn to a hazel nut. When the nodules were removed, a soft under-layer of carbon remained, and with the finger nail this could be removed, developing a perfectly round pit from ⅛ to 3/16 of an inch deep, but in no instance had the pit perforated the pipe.

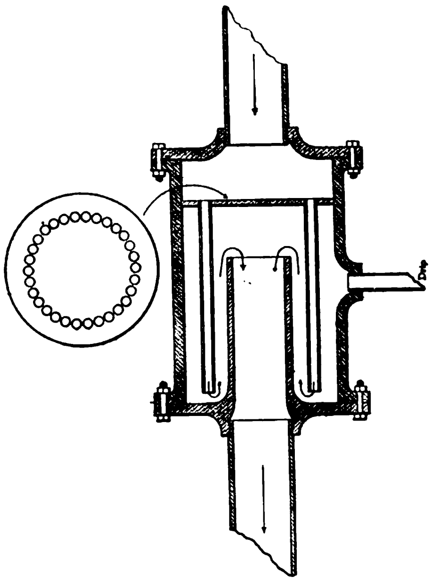


FIG. 3.—GREASE TRAP.

A test with a pressure gauge on the outflow pipe at the extreme end of our lines shows 39 lbs., with 60 lbs. at the station, or a loss of 21 lbs., due to friction. At the same time the pressure on the return line was 28 lbs., and as the friction should be the same on both lines, the difference may be accounted for by the fact that the return line discharges into a tank 15 ft. high at the station.

In calculating the size of mains for a given number of houses, it became necessary to know the relative friction of hot water as compared with cold. To my surprise, I was unable to find any data that was of value, and to settle the question I made some tests which may be useful in future work. A run of 450 ft. of 1-in. wrought-iron pipe with numerous bends was connected to a heater, and the water passed through a meter. With a constant pressure of 10 lbs. the following cubic feet of water were delivered at the open end of the line in five minutes:

At 34 deg. Fahr...6.2
At 60 deg. Fahr...6.3
At 90 deg. Fahr...6.4
At 120 deg. Fahr...6.5
At 150 deg. Fahr...6.6
At 185 deg. Fahr...6.75
At 212 deg. Fahr...7.9

An average of 15 gallons a minute is required to be delivered at each house, and knowing the friction of cold water, the data thus obtained enabled me to calculate the size of mains necessary to give good service to each house, and to always maintain a sufficient difference in pressure between feed and return mains to insure rapid circulation.

As exhaust steam heating from central stations has been introduced to a limited extent, it may not be out of place to call attention to the objections to steam, which do not apply to hot water.

1. The exhaust not being uniform in power plants throughout the entire period of 24 hours, either live steam must be used during the minimum load, or exhaust must be lost during the maximum load.

2. Excessive cost of laying steam mains, which must be large and thoroughly protected from infiltration of water. The temperature of pipes being above the boiling-point of water, any infiltration is converted into steam, and thus a vast amount of heat is dissipated.

3. It is absolutely necessary that from 5 to 15 lbs. back pressure shall be carried on the engine, which is exceedingly wasteful.

4. The condensation of steam is wasted, and with it a large percentage of heat.

5. The piping of houses is expensive on account of the large sizes required to convey steam with 1 or 2 lbs. back pressure.

6. The service is not satisfactory on account of difficulty in regulation, especially in mild weather.

7. The offensive smell, due to vents and leaky stuffing boxes.

8. Water hammer, due to condensation in house pipes.

9. The quality of heat, especially where direct radiation is used.

10. Danger from fire, which has been abundantly demonstrated, can arise from long-continued contact of steam pipes with wood, in an inclosed place.

11. Greater loss by radiation in ground, due to an average higher temperature of mains.

12. The necessity for sewer connections to remove condensation in mains where traps may form.

13. The rapid destruction of all iron drips, due to the solvent action of distilled water.

14. The filling of the entire system with air when a shut down occurs for any length of time.

The only counter charge I have ever heard made was, that it required live steam to run the pumps. But this is largely offset by the back pressure on engines in the steam system and can be made a large source of profit by selling the heat, as none is wasted. During the past two years the system I have described has been installed, and is now in successful operation in the following cities and towns: La Porte, Ind.; Mattoon, Ill.; La Crosse, Wis.; Kenosha, Wis.; Alton, Ill.; Portage, Wis.; Boone, Perry, Ida Grove, Iowa Falls, and Mason City, Iowa.

Among Our Foreign Contemporaries

Progress in Wireless Telegraphy.—In a recent issue of the London "Electrician" a lecture is reproduced which Mr. Marconi held recently before the British Royal Institute. As the audience at these meetings is of a mixed kind, a part of the discourse was devoted to elementary explanations. But he also gave a technical account of the improvements which have recently been worked out by him and which are of interest to engineers. One striking point is the extreme diminution which the filings gap of the coherer has undergone; the path through the filings between the two silver electrodes has now been reduced to 0.04 inch. He found that when specially prepared filings were confined in such a very small gap between flat plugs of silver, the coherer becomes absolutely reliable. A far more important practical improvement, however, is the introduction of a special form of induction coil in connection with the receiving instruments. The arrangement is shown in the adjoining figure. The vertical wire a, and the earth wire b, at the receiving station, are not connected directly to the coherer, but to the primary, c, of a small induction coil, the secondary, d, of which is connected to the ends of the coherer, j, one of the connections passing through a condenser, e. The local battery is shown at b, and k is the relay working the telegraph instrument; f, h, are choking coils. Merely by adding this simple appliance to the apparatus used during the naval manoeuvres, and without otherwise altering the conditions in any way, the maximum possible signalling distance was increased from 7 to 60 miles. It is particularly interesting to learn that it is not every induction coil that will work, but that it must be specially wound, as shown in the adjoining figure, where P is the primary and S the secondary of the coil. To distinguish it from the secondary, the primary is shown as a thick line, although usually the wires of both are of exactly the same diameter. The end, A, of the primary is connected to the vertical wire, and E is the end connected to earth; I is the end of the secondary which is directly connected to the coherer and C is the end connected to it through the condenser; G is a glass tube, on which the coils are wound. The diagram is a greatly enlarged half longitudinal section, but is not drawn strictly to scale. Instead of showing the section of the earth coil or a layer of wire as a longitudinal row of dots or small circles, as it would actually appear, it is shown as a single continuous longitudinal straight line. The secondary of this transformer is wound in several sections, but the peculiarity here is that the sections must be connected together in the way shown in the figure, and as the distance from the primary increases the number of turns in each section must diminish. If the sections are connected otherwise it will not work. An editorial in the London "Electrician" calls attention to the fact that in spite of the announcement, made some time ago, that Mr. Marconi had succeeded in confining wireless telegraphic messages to the instruments destined for their reception, nothing was said about this in the discourse.

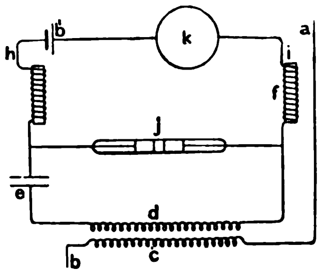


FIG. 1.

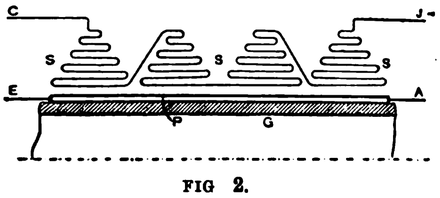


FIG 2.

High-Tension Safety Device.—In a recent number of the London "Electrician" there was a description of an interesting device, invented by Mr. G. W. Partridge, to prevent the danger that may arise in a system of high-voltage alternating-current distribution mains by the connection or removal of a section of the circuit at the switchboard, which may cause a momentary excessive rise in the pressure on the mains and thereby produce a breakdown of the cables and of transformers or other apparatus in circuit. The construction of the apparatus is shown by Fig. 3. In this diagram, c is the inner and c_1 the outer conductor of the concentric cable to be protected. Connection is made from the inner conductor, c, through a gland in the box to an insulated knob, v, which makes, with the knob, v_1, an adjustable spark gap. The path of the stray current after leaping the gap, is from v_1 to a, one of a pair of metallic horns, the width between which increases with increasing height. The gap between the two horns is normally short-circuited by a metallic lever, h, which is pivoted at s, the arm of the lever carrying an iron core, i, which is suspended at the opening of a solenoid, k. The circuit of the stray current is therefore first across the gap, thence along the horn, a, and the lever, h, whence it passes through the coils of the solenoid, k, and finally through a resistance, d, to the outer conductor, c_1. The passage of any considerable discharge across the gap energizes the solenoid, which attracts the iron core, thus lifting the tip, g, of the lever until this strikes the outer horn, l, at the point l'. The flash which will be produced between the horn, a, and the tip, g, will be transferred to the two horns at this point, where the gap is sufficiently wide to allow the convection currents to lift the flash bodily upward until it is extinguished by the widening of the gap between the horns. In operation this device is said to be remarkably prompt.

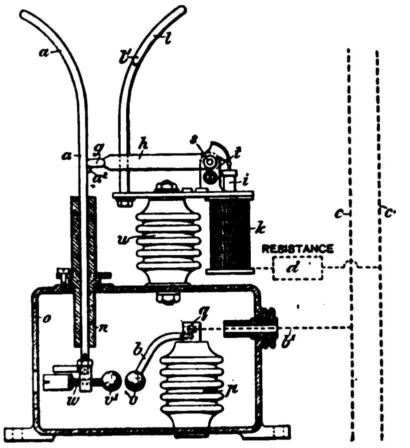


FIG. 3.

A Peculiar Railway Arrangement.—A recent issue of "L'Energie Electrique" contains an interesting description of the tramway system of Palermo, the capital of Sicily. The whole length of the line is 19 miles; on one part of about 0.9 mile length, from Rocca to Monreale, there is a heavy continuous grade of 7 to 12 per cent. This is provided for in the following way. There is a double track, one for the cars running down the hill, the other for those running up; whenever a car runs

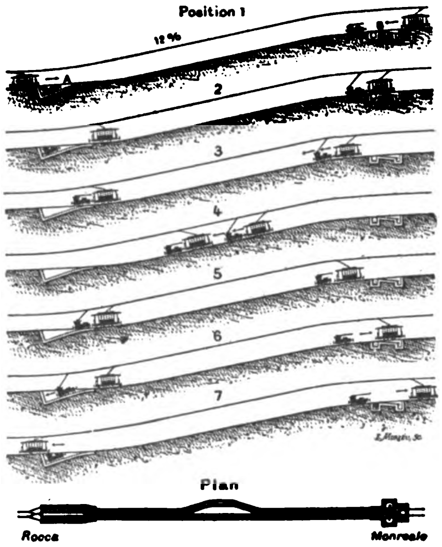


FIG. 4.

down, another runs up. Both are, on this part of the line, coupled to an electric locomotive, the two locomotives being connected together by a metallic cable running on loose rollers and passing, at the upper part of the grade, around a drum. At the lower end of this part of the line the locomotive runs into a pit high enough to allow the car to pass above it. Each locomotive is provided with a single 60-kw. shunt-wound motor and weighs 7½ tons. During the whole performance only the locomotive going down is driving; if necessary, the motors of the car coupled to it could be used in addition. It is, however, impossible to use the motors of the locomotive and car running up the hill, as this would disturb the tension on the cable, which must always be uniform. Direct current at 500 volts is used; connection is made with the descending locomotive by means of a trolley, the rails being used for the return current. The various portions of the cars and the method used are shown clearly in Fig. 4. Position 1 shows the arrival of two cars at the upper and the lower ends of the grade; No. 2 shows the lower car after it has passed over its locomotive and the upper car is ready to push the locomotive; positions 3, 4 and 5 show the beginning, intermediate part and end of one trip; in position 6 the lower locomotive runs into the pit, and in position 7 the cars continue their normal run to the city. The electric railway has been installed quite recently, the current being furnished from the lighting station, which has been in operation since February, 1899. The power house contains an accumulator battery of 196 Tudor cells of a capacity of 3500 ampere-hours at normal discharge and capable of giving 800 to 900 amperes for three hours. For lighting, the three-wire system is used with 150 volts at the terminals of the lamps. There are three multipolar dynamos, the exciting current being furnished by the battery. One dynamo has a single armature giving 1060 amperes at 300 to 350 volts. The other two dynamos have two armatures, each giving 530 amperes at 300 to 350 volts; the latter for traction service and in parallel for the lighting service.

Electrolytic Production of Alkalies and Chlorine.—The electrolytic production of caustic alkalies and chlorine has recently become a very successful field of electrochemistry. The Castner cell and the Rhodin cell, which have been in commercial use for some time, are both mercury cells, i. e., mercury is used as cathode material, so that when electrolysis is produced the mercury forms an alloy, or amalgam, with the sodium or potassium at ordinary temperatures, and thus removes the liberated metal from further action. In both these cells the mercury is on the bottom of the cell and the salt solution is above it; the active surface of the mercury is therefore uppermost. The amalgam is formed at the upper surface and, being lighter, floats upon the mercury as a crust, which from time to time must be removed; in the Castner and in the Rhodin cells this is accomplished by mechanism which is somewhat troublesome. In a recent issue of the London "Electrical Review" Mr. John B. C. Kershaw describes two new forms of mercury cells in which the amalgam is removed automatically by gravitation. The first of the two cells described is extremely interesting, and is shown by Fig. 6. It is an invention of two Italians, Messrs. H. Crudo and J. Bisazza. In their cell the lower surface of the mercury is the active part of the cathode; when the amalgam forms there it rises on account of its smaller specific gravity through the supernatant mercury, so that the renewal of the cathode active surface becomes entirely automatic in character. A second novel feature of the cell is the use of sulphide of iron in order to effect the rapid decomposition of the amalgam when brought into contact with water. The simplest form of the cell is illustrated by Fig. 5, in which A is a glass or glazed porcelain vessel provided with a porous bottom which is covered with mercury; above the mercury is water or a weak solution of sodium hydrate; electrical contact with the mercury is made by means of a spiral of iron wire. The vessel, A, is suspended in a second vessel, B, containing a solution of common salt and an annular anode of sheet platinum, M. On closing the circuit the current passes from M through the salt solution to the mercury in A, and sodium is liberated at the lower surface of the mercury, forming an amalgam which rises through the supernatant mercury and floats upon it. The amalgam comes into contact here with the water and the lumps of ferrous sulphide, and is rapidly decomposed into its original mercury and a solution of sodium hydrate, with an evolution of hydrogen gas. This is, however, only a laboratory cell, showing the principle; two cells, designed for operation on a larger industrial scale are illustrated by Figs. 6 and 7. It has been found, however, that with all these forms of cells, the chlorine passing from the anode compartment of the cell contains hydrogen. Fig. 8 shows a cell which has been designed to overcome this defect. A is a porous tube containing the mercury, and connected with the cathodic compartment of the cell by the non-porous tubes, B, K and L. The amalgam formed in A is displaced by gravitation and rises slowly, passing over into C, this upward movement being also assisted by any hydrogen that may be liberated in the tube, A. In C, the amalgam is at once decomposed by its contact with ferrous sulphide and water, and the regenerated mercury finds its way back into A by way of the tubes, B and K. The enclosure of the mercury in a porous cathode tube and the inclination of this tube in the anodic compartment of the cell in the manner shown cause both the hydrogen and the amalgam to be carried into the decomposing chamber automatically, and the chlorine passing from the anodic compartment of the cell is therefore entirely free from hydrogen. The disadvantage of this cell appears to be the diaphragm, because it is always troublesome to keep a diaphragm in good order; moreover, it increases the internal electric resistance. Nevertheless, the process is very ingenious and appears to be extremely simple. It does not seem to have been introduced commercially, yet.

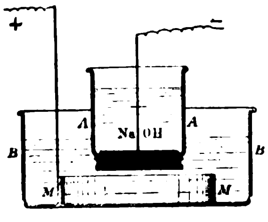


FIG. 5.

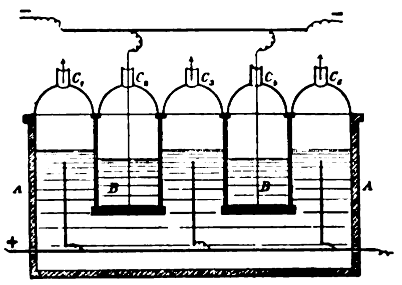


FIG. 6.

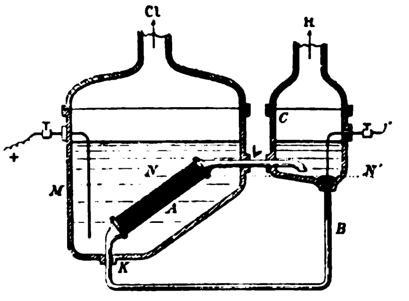


FIG. 8.

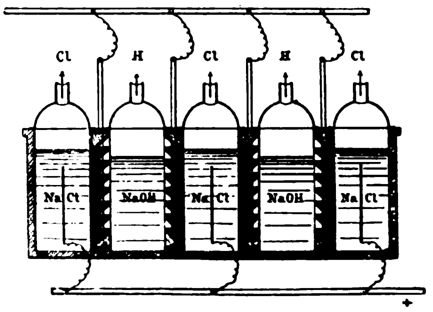


FIG 7.

Differential Telemicrophonic Relay.—In a French Academy note which is reprinted in "L'Industrie Electrique," "L'Eclairage Electrique," and "L'Electricien," Mr. E. Mercadier describes a new improvement of his system of multiplex telegraphy. His system is based on what is called a "monotelephone," that is, on the use of telephones which will vibrate only for certain definite frequencies, each telephone and its corresponding microphone being tuned to the same frequency. Each microphone is actuated by an interrupted current produced with the aid of a tuning fork. The system was devised a number of years ago and was exhibited in Chicago in 1893; but it was rather imperfect at that time. The improvement described in his recent Academy note consists in a "differential telemicrophonic relay" which collects at both the transmitting and receiving ends all signals made by sinusoidal currents of frequencies varying from 480 to 900 per second; these currents constitute 12 notes, differing from each other by a semitone. The apparatus, which is represented by Fig. 9, consists of a telephone whose diaphragm, d, is 4 ins. in diameter; upon the core, n, of the electromagnet two identical coils are wound. There is also a microphone, consisting of a small plate of carbon, p, screwed to the center of the diaphragm, and of another carbon contact, C, attached to a metallic mass, m, held by a flat spring, r, which is fixed on the frame of the telephone, but insulated from it by an ebonite plate, o. The screw, V, enables the electromagnet to be adjusted with relation to the diaphragm; the screw, V', provides for an adjustment of the pressure of the microphonic contact, C, c. T, T' and t are rubber tubes to prevent the effects of foreign disturbances. One of the coils of the electromagnet, n, is connected to the circuit of the line, and the other to an artificial line—in order to obtain differential duplexing common in ordinary telegraphy. This duplexing is also accomplished in his multiplex system of telegraphy with oscillating currents, by means of very simple special arrangements. The mass, m, the contact, C, the spring, r, the plate, p, and the diaphragm, d, are inserted in the circuit of a cell and of the primary windings of an induction coil, while the secondary winding is connected to twelve receivers, corresponding to the twelve transmitters. If a number of signals transmitted by oscillating currents of different frequencies pass over the line, each of the twelve receivers responds to the current of the frequency to which it is tuned without being affected by the other currents. Trials with the system between Paris and Toulouse, Paris and Bordeaux, Paris and Pau, over lines of 375 to 500 miles, are said to have been very satisfactory.

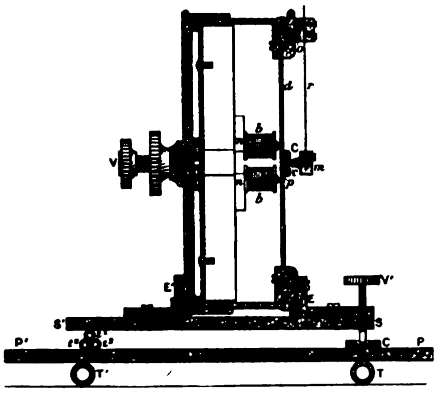


FIG. 9.

Maximum Demand Indicator.—In a recent issue of the London "Electrician" and of other English journals, we notice a description of a maximum-demand indicator, devised by Mr. E. C. Rimington, and intended to be used in connection with an electrolytic meter. As the maximum-demand system of charging is known in this country also, and as the indicator in question is very simple and ingenious, it may be of interest to describe it here. Its action is not directly electrical, but consists in utilizing the pressure of the escaping gases evolved in the electrolytic house meter; as a consequence, absolutely no electrical energy is consumed by the demand indicator, a fact which gives it a great advantage over other indicators. As shown in Fig. 10, it consists of a U-tube, AA', one limb of which is connected by a flexible tube to a glass tube, K, sealed into the top of the electrolytic meter in such a way that the gases evolved are carried off through this tube. The other limb is provided at its upper end with a porous plug, G, the purpose of which is to act as a damper and prevent too violent a movement of the liquid contained in the lower part of the U-tube. At the upper end of the limb, A, another plug, C, is connected; the gases evolved escape through this plug. Thus the rate at which these gases are evolved determines the pressure of the gas in this part of the tube, and this rate is proportional to the current passing through the meter. The effect of this pressure is to force the liquid down in the limb, A, and correspondingly to raise it in the limb A^1. All the liquid raised above a certain point in the limb, A^1, overflows into a vertical tube hanging at the point, D, and this tube is provided with a by-pass, H, to allow of the free escape of air displaced by the liquid flowing into it. The maximum current passed through the electrolytic meter, therefore, is indicated by the height of the liquid in the vertical tube just referred to. It is evident that the precision of the indicator depends upon the tightness of the various joints and on the porosity of the plugs.

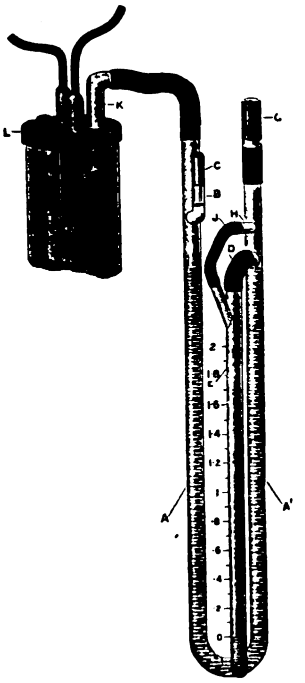


FIG. 10.

An Electric Brake-Dynamometer.—In a recent issue of the "Elektrotechnische Zeitschrift," Prof. A. Grau describes an interesting electric brake dynamometer which is illustrated by Fig. 11. Upon the axle of the machine a copper disc, S, is mounted, which rotates between the pole-pieces of a horse-shoe electromagnet. This magnet is mounted on the shorter arm of a beam scale, while the longer arm carries an adjustable weight, G. When the electromagnet is excited, and the disc rotates, eddy currents are induced in it which act as a brake upon the rotation of the disc. For a constant number of revolutions of the disc and for a constant excitation of the electromagnet, this braking action is constant and can be determined by balancing the scales by means of the adjustable weight, G. The braking force can be varied between wide limits by the variation of the magnet excitation, as well as by the distance between the poles. The instrument was used for the determination of the work of an electric motor and was found to work satisfactorily.

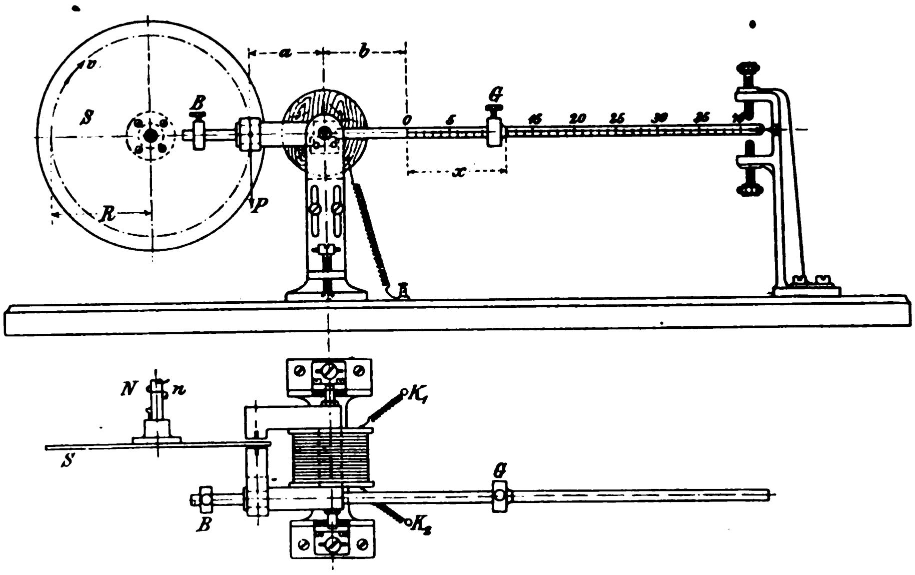


FIG. 11.

Concentric Cables for High-Tension Alternating-Current Circuits.—In a recent issue of the "Zeitschrift fuer Elektrotechnik," Vienna, Dr. G. Stern describes an automatic safety device which enables the current to pass from the external conductor of a concentric cable to earth, when the potential difference momentarily exceeds a certain value. The device, shown by Fig. 12, is similar to a lightning arrester, and consists of a pair of toothed plates, a, b, made of non-arching metal, separated by an air gap. A fuse-wire, which connects one of the plates with the earth, is connected with the shorter arm, c, of the metallic lever, so that when the current becomes excessive and the fuse-wire melts, the lever is released and falls by its own weight, short-circuiting the air-gap. It may be connected with a signalling apparatus which indicates that the device has operated, notifying the attendant to reset it.

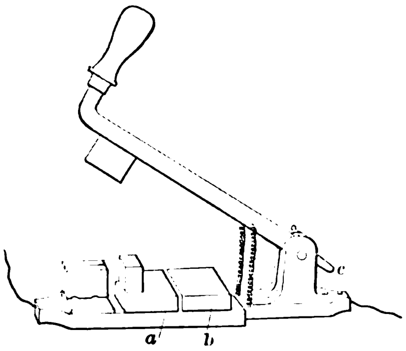


FIG. 12.

◆

Pipe Joint Resistance and Electrolysis.

To the Editors of American Electrician:

Sirs:—I have read in your April issue, Mr. Albert B. Herrick's comments on my article which appeared in your March number, on the subject of the effect of joint resistance in water mains. Although I am averse to continuing the discussion, there are some points which seem to call for a reply.

Before doing so, however, permit me to correct an error in my former communication to the effect that, so far as I was aware, Prof. Lucian I. Blake was the first to discover electrolytic damage to the interior of pipes at an investigation made at Kansas City, Mo. I think this credit belongs to Mr. D. H. Maury, consulting engineer of Peoria, Ill., who reported such inquiry in 1894 on a 16-in. cast-iron pipe and also again on a 20-in. main in 1896.

Mr. Herrick's assertion that he has not found electrolytic action under 0.6 volt difference of potential at the joints, and that 316 volts per mile are required to do any damage, does not indicate an extensive observation and is contrary to the experience of electricians who are informed on the subject.

The grounded circuit in connection with water mains is a combination of metallic pipes and wet earth at the joints which the current follows, passing in and out from one to the other; according to their relative conductivities; and wherever it leaves the pipes for such earth carries some metal with it. The fact of such injury with almost infinitesimal voltage is established beyond question by many examples.

Mr. Herrick's expression, "dams the current flow," may well apply to many trolley railway tracks—for example, a recent examination by the writer disclosed a current so effectually "dammed" by the rail-joint resistance that about nine-tenths of the current left the rail for the pipe—earth circuit.

As to Albany, the writer has personally examined and seen within a few months unmistakable electrolytic pittings there on cast-iron water mains, which had occurred subsequent to the time when it was bonded to the railway return, and other very serious injury on older cast-iron mains, which had undoubtedly occurred, at least in part, subsequent to these return connections. It is now well known that such connections only relieve acute trouble in spots, while spreading the injury over a large area in both positive and negative districts by bringing more current on the pipes.

The 25 double-trolley roads referred to by Mr. Herrick as existing since 1892 must have existed in his imagination. The "still surviving" Cincinnati system is a very healthy patient, largely developed in later years, and is a well known financial success. I also know from personal examination of that system that it is a marked mechanical and electrical success; as complete in its operation for overhead lines as the New York roads are, for the underground conduit system. That "it has not been sufficiently satisfactory to encourage engineers to advise the double overhead construction on any roads" is incorrect; very naturally the single trolley, because of its somewhat cheaper construction, has been generally installed; but the Cincinnati system is the basis of the recent acts of Congress, under which the same system has been introduced into the District of Columbia.

Mr. Herrick evidently does not speak from personal knowledge of the Cincinnati system. If he did, he would know that the only lines upon which cars could be operated "without the negative trolley being in contact with its trolley wire," are the two railways belonging to other companies which enter the city and operate with a combined double and single trolley grounded circuit, from power houses outside of the city, which have their negatives grounded in the usual manner.

The injury that is being done by these trolley currents is not growing less, but it well known to be enormous all over the United States. The question is not, Does the injury exist? but how long will the owners of underground piping systems submit to the destruction of their property?

A. A. Knudson.

New York, April 25th, 1900.

Some Recent Electrical Patents.

A Load-Equalizing Connection for Motors Geared Together.—When two direct-current shunt-wound motors are mechanically coupled or geared to the same load, their armatures being in parallel with each other across the lines, any slight inequality of field strength tends to shift a large per cent. of the whole of the load from one to the other. For instance, if the drop in speed from no load to full load is five per cent., and one motor has a five per cent. stronger field than the other, the one with the weaker field will take the whole load, the back e.m.f. of the other one being sufficient to prevent any current being forced through it. To overcome this difficulty Mr. Frank J. Sprague connects the armatures of the two motors in series with each other across the lines, the fields also being connected in series with each other between the positive and negative terminals. In this way the same current must pass through the two armatures, and if the fields are of nearly the same strength, the torque developed by the two motors will have nearly the same value. A discrepancy of five per cent. between the field strengths of the two machines will, in this case, cause only a five per cent. difference between the torques developed by the two machines instead of throwing the whole torque upon one motor, as would be the case were the two machines connected up independently across the lines, as pointed out above. Fig. 1 shows a plan of a two-motor elevator of the type built by the Sprague Electric Company for the Central London Underground Railroad, in which this scheme of connection is used. The two motor armatures are on separate shafts, each of which drives two worms, one right-handed and one left-handed, so as to balance the end thrusts, the two worm-gear shafts being geared together, one carrying the winding drum. The claims of the patent cover only the simple feature of series connection of the armatures. Patent No. 647,240.

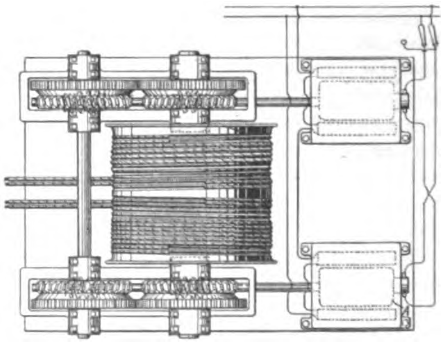


FIG. 1.

Combined Transformer Winding and Cooling Coil.—In oil-insulated and water-cooled transformers it is customary to put the water-cooling coil in the upper part of the case, allowing the oil to circulate from the heated core and coils below to the cooling pipes above, transferring the heat from one to the other. A much more direct application of the cooling is obtained by interspersing the cooling coils between the layers, as is done in some of the large transformers at Niagara Falls, and an even better application of the cooling medium to the seat of the heating is obtained by making the low-tension winding in the form of a tube in which the water is circulated. A construction of this kind has been patented by Mr. W. S. Moody of the General Electric Company. The general features of its design are shown by the section through a transformer, reproduced in Fig. 2. This transtransformer is of the shell type, with its laminations laid in a horizontal plane and its coils in a vertical plane. The secondary, K, is a flattened drawn-copper tube, with water-tight brazed joints, its several turns being interspersed in the usual way between the flat primary layers. Where the terminals rise through the cover of the transformer the hollow interior opens into the inlet and outlet pipes, O, either or both of which can be connected to the supply or discharge system by means of rubber tubing to prevent the piping from short circuiting the secondary. A plug opening, L, is left at the top of each turn, so that water can be syphoned from the interior in case the transformer is to be shut down and left at a temperature below the freezing point. Similar provisions are made for other contingencies likely to arise in an unusual construction of this class. Patent No. 646,500.

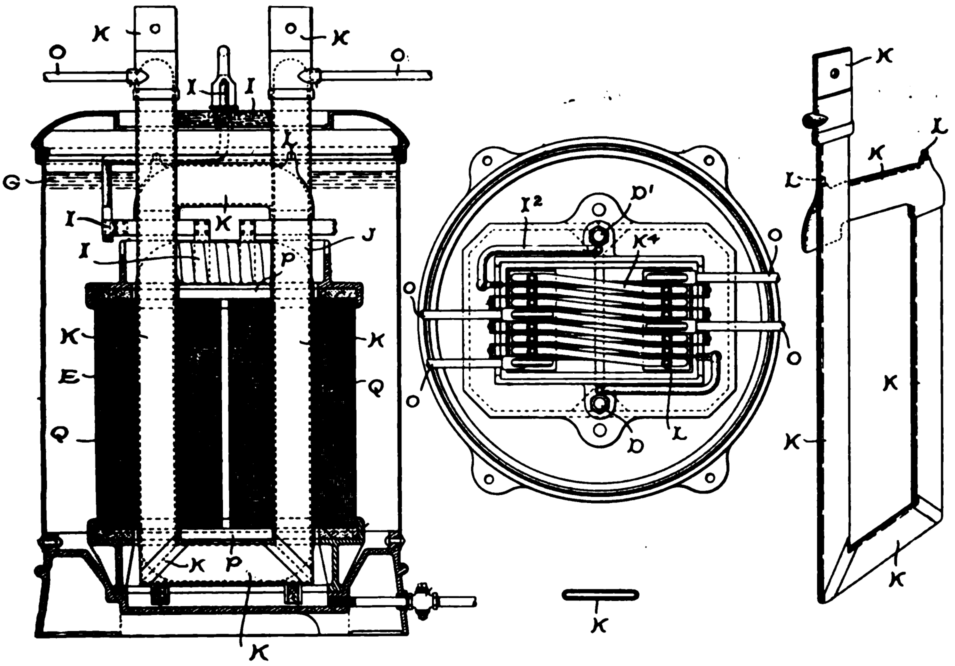


FIG. 2.

The Structure of Double-Current Generators.—When a double-current dynamo is direct coupled to one end of an engine shaft it is preferable to mount both the commutator and collector rings on the outboard end of the machine. If the commutator is of large diameter its supporting frame may be made annular and the collector rings may be mounted directly within it. This construction has been adopted on some General Electric double-current machines, notably those used by the Chicago Edison Company, and described in the American Electrician of October, '99. The arrangement of the parts of one of these machines is shown in Fig. 3, which is reproduced from a patent issued to H. G. Reist. The three collector rings, 8, 8a, and 8b, for three-phase currents, are mounted on the hub, 7, and clamped in place by the end ring, 11, being insulated from each other by the annular barriers, 10, and connected to the machine windings by means of a number of bolts, such as that shown at 12. Outside of this collector-ring structure, the commutator is made up of the usual bars, held in place by segmental clamping plates. A notable feature of this commutator is the use of a pair of annular rings of insulating fiber, 14 and 14a, rising above the surface of the commutator. These annular barriers of insulating material are made up of segments held in line with each other by dowels. The claims of the patent are limited to these insulating rings rising above the face of the commutator. Patent No. 644,684.

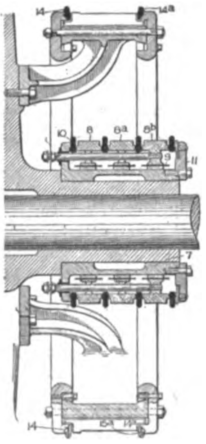


FIG. 3.

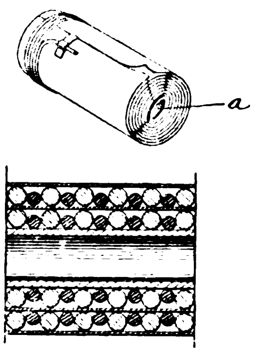


FIG. 4.

Fine Wire Winding for Magnet Coils.—The high-resistance magnets made by the Varley Duplex Magnet Company are, as is well known, wound with bare copper wire, as shown in Fig. 4, the insulation between turns being obtained by interwinding a silk or cotton thread between the turns, the insulation between layers being obtained by wrapping a sheet of paper over each layer of wire and thread. Mr. James C. Anderson, an engineer connected with the company, has patented a scheme of winding by which each automatic-winding machine becomes multiple. The machine winds a long continuous rod or tube of coils, consisting of several independent coils, on one core, as shown in Fig. 5. After these are wound they are sawed apart on lines x, y. In this way the capacity of one of the winding machines is greatly increased, especially when winding short coils. Patents No. 644,311 and 644,312.

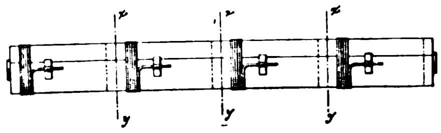


FIG. 5.

Bonds for Water Pipes.—To prevent the electrolysis of underground piping, even with well-designed systems of auxiliary returns, Mr. A. A. Knudson has patented the use of bonds across the joints of such pipes. The readers of these columns will remember that Mr. Knudson recently pointed out this difficulty in an article which appeared in this paper. The patent described various forms of bonds for ordinary caulked joints, the claims broadly covering any type of bond enclosed within such a joint. Patent No. 646,742.

Distribution of Power for Long Electric Railway Lines by Means of Gas.—The plan recently proposed by Mr. George Westinghouse to supply direct current for long-distance electric railways by means of sub-stations operated by gas engines, the power being transmitted from the central station by means of a high-pressure gas-pipe line instead of in the form of high-tension polyphase currents, has been covered in two patents issued to Mr. Westinghouse on March 20th. The patents describe the well-known objections to the use of the ordinary arrangement of engines, alternating-current generators, high-tension lines, transformers and rotary converters in the case of long-distance railway systems with infrequent train service, and point out the comparative advantages of distributed gas engines driving direct-current generators scattered in sub-stations along the line. In the case of a line having trains at intervals of 20 minutes to an hour, the patents propose that the sub-station shall be shut down when there is no train on the section of the road supplied by it, the engine and generator being started up in time to supply the next train as soon as it enters the section. The patents even describe an automatic arrangement for doing this without the presence of an attendant in the sub-station. The claims of the patent are extremely broad, covering combinations of simple methods and devices already well known in the art. For instance, one claim covers the method of supplying a section of the road from a local sub-station or from adjacent sections when the demand for current in the first section exceeds the normal output of the corresponding sub-station. Another claim covers the method of supplying sections from local sub-stations, indicating at these sub-stations the demand upon the sections, and operating the generators to correspond with such demand. Patents Nos. 645,612 and 645,613.

NEW BOOKS.

Indicator Diagrams. By W. W. F. Pullen. Manchester (Eng.); The Scientific Publishing Company. Cloth; octavo; 240 pages, 261 illustrations and three tables. Price, 6 shillings.

As the name of this book intimates, it is devoted to steam engine indicators and their diagrams. All of the leading English types of indicators are described, and instructions for their use are given. The causes affecting the shape of an indicator diagram are discussed, and profuse examples of diagrams taken from practice are reproduced. There is an interesting chapter on pump diagrams, liberally illustrated with examples, and one on the subject of diagram integration or "averaging," in which only the Coffin and Amsler planimeters are represented, and the latter very poorly. Speed-counters and the well-known rope brake are briefly described, and formulas applying to the brake are given. The final chapter is devoted to a brief explanation of the Boucher ("watch-case") type of slide rule. The book is sound and should be valuable as a reference book for engineers already familiar with the principles of indicators, planimeters, and experienced in their application. It is not sufficiently elementary, however, to serve as a text book for the untrained worker.

The Use of the Slide Rule. By F. A. Halsey. New York: D. Van Nostrand Company. Boards; 84 pages, 3¾ x 6 ins.; 18 illustrations. Price, 50 cents.

This is chiefly a compilation of a series of admirable articles of an elementary character which originally appeared in the American Machinist. The author explains in simple language the logarithmic principle upon which the slide rule is based, and gives profuse examples of calculations. A valuable feature consists of pictures of slide rules set for various calculations—object lessons, so to speak.

Dynamometers and the Measurement of Power. By Prof. John J. Flather. New York: John Wiley & Sons. Cloth; 394 pages, 4½ x 7¼ ins.; 116 illustrations; 11 tables. Price, $3.

The second edition of Prof. Flather's excellent treatise, comprising all of the matter included in the first edition and a great deal additional. Five chapters have been added, one devoted to the power required to drive machinery and four on the measurement of electric power, and instruments required for this work. The book has been brought right up to date; the chapter on transmission dynamometers has been enlarged by descriptions of several new types, and the electrical section includes methods for measuring the output and efficiency of alternating-current (single and polyphase) motors. The book has the merit, too, of being authentic and reliable, which is a vitally important feature to those who are not able to verify an author's statements and rules for power measurement.

Condensers. By F. R. Low. New York: The Power Publishing Company. Limp linen; 80 pages, 6x9 ins.; 32 illustrations; 13 tables. Price $1.00.

This is a practical exposition of the principles governing the operation of condensers and a thorough explanation of the apparatus employed in practice. The explanations are couched in simple language, yet the accuracy and thoroughness are not sacrificed in any detail. The book gives suggestions as to advisability of condensing under various conditions, and instructions for starting up and shutting down engines equipped with condensers. The tables are valuable, particularly those giving the output and ratings of various makes of air pumps.

Compound Engines. By F. R. Low. New York: The Power Publishing Company. Limp linen; 52 pages, 6x9 ins.; 37 illustrations. Price 50 cents.

This is a companion piece to the book above reviewed, being written in Mr. Low's attractive and intelligible "lecture" style, for practical men. It explains fully the reasons for compounding an engine and contains a most excellent chapter on the subject of combining the diagrams from low and high pressure cylinders. The book is well worth several times its price to anyone who has to do with the operation of compound engines.

The Gas Engine Hand Book. By E. W. Roberts. Cincinnati: The Gas Engine Publishing Co. Cloth; 220 pages, 3½ x 5¼ ins.; 39 illustrations.

This little book is eminently practical in character, treating of the care and management of gas engines, causes, troubles and their remedy; comparisons of gas and gasolene engines; descriptions of igniting devices and governor mechanisms, and gas engine starters. The principles of operation are discussed sufficiently to enlighten the practical man as to how and why the various phenomena occur, but the text is pleasingly devoid of forbidding thermodynamic propositions in highly mathematical form.

NOTES.

A New Multiplex Telegraph System.—M. Mercadier, a French inventor, is said to have devised a simple system of multiplex telegraphy. At a recent test between Paris and Pau it is said that 12 messages were satisfactorily transmitted in each direction on a single circuit.

The Telegraph in Baluchistan.—A combined postoffice and telegraph office has been installed at Panjpai, the intermediate station between Quetta and Mishki on the Kafila trade route recently opened, and the system is being rapidly extended. It will ultimately terminate at the border of British territory, a little over 300 miles from Quetta.

Castings and Punchings for Small Dynamos.—Mr. J. C. Brocksmith, who is the designer of the single-phase rectifier described in the June, 1899, issue of this paper, is prepared to furnish complete castings and armature stampings for the machine in the modified form of a direct-current, 110-volt dynamo. The output of the modified machine will be ½ kilowatt.

Lack of Appreciation in Turkey.—According to press dispatches the Turkish government has issued a decree prohibiting the importation of electrical apparatus. The Sultan does not seem to be so progressive as the Mikado of Japan, who has ordered the installation of electric lights in some of the rooms of the Imperial Court at Tokyo, on trial.

Smoke Prevention Impossible?—A rather rather peculiar combination of engineering and judiciary judgment is afforded by a recent legal decision which declares the smoke ordinance in Denver, Colorado, unconstitutional. The ground on which the decision is based is the opinion that no device exists for the adequate prevention of smoke as provided by the ordinance.

Automobile Charging Stations on the Jersey Coast.—The New Jersey Electric Vehicle Transportation Company has arranged to establish charging stations along the Jersey coast for the convenience of automobilists this summer. Stations will be put in at Sea Bright, Long Branch, Allenhurst, Spring Lake and Atlantic City. In addition to furnishing charging current the stations will carry in stock automobiles of various designs, both electric and gasoline, for hire.

Oil Fuel in Power Houses.—The San Diego Electric Railway Company has installed oil burners under the boilers in this power house, and a tank having a capacity of 20,000 gallons of crude oil has been erected to receive oil supply directly from railway cars. It is estimated that the use of oil as fuel will result in a saving of $18 per day, but neither the price of coal in that locality nor the price of delivered oil is stated.

Electric Canal Haulage in New Jersey.—The Delaware & Raritan canal, which recently determined to substitute electricity for mule power, has received its first electric motor. The system contemplates the use of automobile motors which are to travel along the tow path and haul the boats. Under the old system of mule traction the speed was about two miles an hour; with the new system it is expected to make a speed of about five miles an hour.

A Miniature Electric Railway.—A unique electric railway is in course of construction in a private park at Macon, Mo. The railway is a mile in length and 3 ft. 2 ins. in gauge. Each car will accommodate eight passengers and the train will be illuminated, of course, by incandescent lamps. Current will be supplied from a nearby academy power plant through underground conductors. The railway is being built for the benefit of the children of wealthy families, one of which owns the park through which the line runs.

Gas Engines as Prime Movers—In a paper read before the Birmingham Association of Engineers, England, Mr. W. Arnold stated that gas engines can compare favorably with steam engines as prime movers up to about 60 h.p. and in smaller sizes possess many advantages over the steam engine unless steam be required for heating, drying or other purposes. There was a deplorable lack of basic data in the paper, such as the price of coal, class of steam engine, class of gas engine, kind of gas considered, etc., which affect the operation of such engines somewhat.

Electric Railways in Russia.—A correspondent of the Philadelphia Commercial Museum writes in from Riga to the effect that the city is considering the construction of a network of electric street railways, and that the Ministry of the Interior has expressed a willingness to grant the city a loan for this purpose. The cities of Lodz, Minsk and Witebsk already have electric street-railway systems running, and similar systems are in course of construction at Ludin and between Pabianice and Zgierz by way of Lodz. The system used is the overhead trolley.

Searchlights Prohibited in London Streets.—The London County Council has passed regulations which provide that "no person shall exhibit any flashlight or searchlight so as to be visible from any street and to cause danger to the traffic thereon." The word "flashlight" is defined as "any light used for the purpose of illuminating, lighting or exhibiting and sign, word or device, etc., which alters suddenly in intensity, color or description." A "searchlight" is defined as "any light exceeding 500 c. p. which alters either in intensity, color or direction." The saving clause is the requirement that danger must be proved.

Incandescent Lighting in New York.—On April 1 the New York Gas, Heat, Light & Power Company had connected to its system the equivalent of 1,375,826 16-c.p. lamps; this system includes the old New York Edison system. The circuits of the United Electric Light & Power Company had connected in on April 1 the equivalent of 250,000 16-c.p. lamps, making a total in Manhattan and Bronx of 1,625,826 lamps. On the Brooklyn side of the river the service will probably show an equivalent of half a million lamps, making a grand total in Greater New York of 2,125,826 16-c.p. lamps.

A New Street Lighting Plant in St. Louis.—The Seckner Contracting Company has obtained the city contract for lighting the streets of St. Louis, Mo., for a period of ten years. The contract is for 900 arc lamps and 600 32-c.p. incandescent lamps, the latter being used in alleys. The rate for arc lamps is $97.50 a year per lamp, and the rate for incandescent lamps is $21.25 a year per lamp. The contract carries with it a franchise for commercial lighting and specifies that all wiring must go underground. The new plant will be located on the river front opposite the Laclede Gas Works. The boiler room is to be equipped with Heine boilers, having an aggregate output capacity of 2000 h.p. The engine room will contain Ideal engines belted to four Wood arc lighting dynamos.

The Use of Platinum in Incandescent Lamps.—It has been generally believed that platinum was used for the leading-in wires of incandescent lamps on account of the fact that its coefficient of expansion is the same as that of glass. Owing to this belief several misinformed inventors have experimented with various alloys and found a means of varying the coefficient of expansion by varying the proportions of the different metals used and thereby obtaining the desired similarity with that of glass. The objection to the use of other metals than platinum is, on the contrary, not discrepancy in thermal expansion, but the fact that all but platinum oxidize. No matter what care is taken to keep oxygen from the metal, a thin film forms around the wire between it and the glass, allowing a slow leakage of air which gradually breaks down the high vacuum necessary for good incandescent lamps.

A Peculiar Damage Suit.—A passenger on a street car was recently ejected from the car by the conductor because he refused to "move forward" to a position in front of a hot stove when told to do so by the conductor. He sued the railway company for $5,000 damages and was awarded the full amount by the Superior Court of Wisconsin, which decided that a street car conductor has no right to order passengers to "move forward." While in the case in point the passenger may have been justified in declining to stand close to the stove, the precedent established by the court decision would, if observed, greatly hamper the operation of street cars in crowded cities. Under this ruling the conductor would have no means of preventing passengers from crowding near the doorways, as they invariably tend to do, and impeding the ingress and egress of other passengers, the result obviously being undue delay in taking on and letting off passengers.

Electricity in Egypt.—A telephone system is in operation in Egypt with headquarters at Cairo and branches in Alexandria, Port Said and other towns. The company has a trunk line running from Cairo to within a few miles of Alexandria but has been unable to complete it on account of government opposition, which is based on the ground that the telephone line would diminish the state receipts from the telegraph system. The telephone company employs male operators only, and these are required to be expert linguists, having to speak English, French, Italian, modern Greek and Arabic. There is also in Cairo an electric lighting central station, supplying the very respectable output of 35,000 10-c.p. lamps. Brown-Boveri alternators, giving 2,000 volts at 40 cycles, are direct-driven by Sulzer engines, and the distribution is through concentric cables. There are 90 transformer sub-stations, at which the current is stepped down from 2,000 to 100 volts.

Electric Smelting in Iron and Steel Production.—Tests of an experimental electrical furnace in a plant of 100 h.p. capacity near Rome are said to have resulted in the production of iron and steel at about two-thirds the usual cost. The apparatus employed is known as the Stassano electric furnace and resembles somewhat a small blast furnace. The heat is supplied by an electric arc between carbons which project into the furnace near the bottom from opposite sides and are adjusted by hand. The ores are carbonates and oxides and the process requires them to be powdered and mixed with such proportion of carbon, lime or silica as may be necessary to produce the desired quality of metal. The powdered mixtures are formed into bricks with 5 or 10 per cent. of pitch under hydraulic pressure, and these bricks are fed into the furnace. The amount of energy required per ton of metal produced is said to be 3000 h.p.-hours, and the length of the process necessary to produce a small ingot was a little over half an hour. The experiments are to be continued with three larger furnaces capable of yielding about 4,000 tons of metal per annum and requiring about 500 horse-power each for operation.

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Changes in advertisements should reach the office of the American Electrician by the 15th of each month in order to appear in the following issue. New advertisements can be received up to the 25th of each month.

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The American Electrician has a larger paid subscription list than any other electrical journal in the world.

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The Paris Exposition Plant.

The impress of American ideas upon European practice in both steam and electrical engineering is slowly but surely becoming manifest. At the Paris Exposition, for example, one finds American-type generators and motors where distinctive German and French designs formerly prevailed; and on the steam side, water-tube boilers and marine-type engines are prominently in evidence. There still remain some typical divergencies, such as the monster single-cylinder engine of French make, developing 1000 horse-power. The preponderance, however, is in the direction of compound and triple-expansion engines, of what would be termed conventional forms in this country. Unfortunately, the Exposition plant is behind the schedule as to installation, so that at the time our article was prepared a complete description was impracticable. The portion covered, however, presents many very interesting features.

Central Station Engineering.

The average central station engineer who is hampered by lack of diversity in experience and the absence of close touch with latest methods, and whose omnigenous duties almost invariably include the selection of machinery, should obtain much assistance from the group of articles on central station engineering which appears in other pages of this issue. Despite space limitations the various authors have brought out forcibly the salient points of their respective themes, and indicated in a general way what is good practice and what may be expected of each type of apparatus available.

Of course, inherent conditions affecting each individual installation preclude any specific recommendation of such and such a boiler, engine or stoker. If one undertook to itemize the cases for which any one type is especially well adapted the result would obviously be a heterogeneous array of tabular matter of such complexity as to be confusing and useless. Although the articles referred to are, therefore, general in character, the generalities are by no means of the class usually designated "glittering," as a careful reader will readily discover by perusal of them.

The Choice of Boilers.

The article on boilers, of the above-mentioned group, brings out several eminently practical points which, although they may seem entirely obvious after they have been indicated, are nevertheless overlooked more frequently than they are remembered. The questions of reliability and facility of repair are vital ones, probably the very first in the list of imperative considerations. The most efficient and best steaming boiler in the world is undesirable for a plant located remotely from a competent repair source, if its design be such as to entail great liability to accident by reason of special construction which is not only unduly vincible, but difficult to properly repair or replace when damaged. For such remote plants the old horizontal return-tubular boiler is without a peer.

On the other hand, for city plants or those in towns situated within easy reach of skilled repairers and duplicate parts, there is little doubt (given a fair quality of water) that some form of water-tube or sectional boiler is usually preferable on account of its comparatively small floor area per unit of output and its quick-steaming ability. Mr. Douglass' article contains much valuable information of a general character respecting both of the classes of boiler in common use. Most readers who have not been painfully enlightened by experience or observation will be surprised to note that the water-tube type of boiler has not shown any great degree of superiority over the ordinary type in point of safety. The popular notion has been that the use of a water-tube boiler was almost tantamount to a guarantee against personal injury to attendants.

In this connection, the material of which the small parts of sectional boilers are made has been the subject of some comment recently. It has been suggested that the tubes might as well be made of heavier pipe than the usual boiler-tube material—ordinary steam pipe, for example, such as is used in some of the marine boilers. It would seem that this might be a fruitful theme for consideration by builders of the thin-tube types of boiler. Of course, any academic discussion of the matter would be absolutely inutile, the only thermodynamic question involved being the heat conductivity of the tubes; it is a pre-eminently practical subject.

Electrical Station Equipment.

It would appear that the full extent of the convenience and efficacy inherent in the unobtrusive motor balancer is just beginning to be realized on this side of the Atlantic, although, as indicated in another column, such machines have been used in England for years. The same statement slightly modified applies to accumulators, the difference being that our appreciation of them is firmly established, but of comparatively recent maturity instead of being in an incipient stage; in Europe their use is almost as common as that of the motor balancer. Mr. Mather's article indicates clearly the great advantages derivable from the proper use of both kinds of apparatus mentioned.

One of the plans recommended in the article will probably find numerous objectors—that comprising the use of a double-current generator for plants in which the incandescent lighting load is widely distributed, is of minor importance, and yet justifies consideration. The use of special transformers in such a plant involves no difficulty or disadvantage beyond the extra cost of the apparatus, provided that "spares" are kept in stock religiously. There is a prospective inexpediency, however, in such an arrangement. The plant may grow to such an extent as to warrant the use of conventional apparatus, in which event the transformers would represent partly wasted investment, as they would need to be provided with new coils of the proper voltage ratio. However, reversing the viewpoint, it might develop that by the time the service had expanded to the point indicated, the special transformers would have become obsolete or have deteriorated to such an extent that rehabilitation would have become necessary, or at least advisable, on general economic principles.

The alternative suggestion of employing four-wire secondary mains balanced by auto-transformers is even less attractive. It involves two multiplex distribution systems, each admirable in itself, but the combination of which is a little disquieting. The two phases must be kept practically equal as to load in order to secure good commutation on the direct-current side of the generator. If the two circuits could be connected in series, as is possible in a two-phase system supplied by an alternator having two distinct armature windings, the plan would be particularly inviting. But this is manifestly impossible because the two circuits are tapped into a single closed armature winding. Connecting one circuit in series with the other would put a dead short-circuit on one-fourth of the armature winding. the result of which procedure requires no detailed discussion.

It would appear that for small plants supplying mixed loads, direct-current apparatus is almost invariably preferable. A 250-volt three-wire system for reasonably compact distribution or a 500-volt five-wire system for wider range, balanced by means of rigidly-coupled motors or accumulators, or equipped with both, leaves nothing to be desired within the limits of reason. Of course, where the load entirely or mostly consists of incandescent lamps the use of a purely alternating-current system is good practice. Except for extremely remote distribution, however, alternating current has no determining advantage over direct current in small stations, under the usual conditions found in practice.

Grouping Transformers.

Since the adoption of 2000 volts as a standard for alternating-current primary circuits, many of the plants which formerly operated at 1000 volts have been changed over to the higher standard. In most cases where such changes have been made the 1000-volt transformers have been utilized by connecting up two transformers with their primaries in series and their secondaries either in series or in multiple, according to the character of the secondary distribution. Such an arrangement is frequently conducive to considerable economy in the secondary circuits, as well as that obviously secured in the primary lines by reason of the doubled voltage. The secondary distribution would preferably be on the three-wire plan, the neutral leading out from the junction of the secondaries which would be connected in series like the primaries.

Thus far the arrangement is perfectly simple and obvious, and it is probable that very few engineers realize that it embodies serious and peculiar liability to the destruction of one of the two paired transformers. The danger lies in the blowing of a fuse in one of the outer leads from the transformer secondaries. Such an occurrence would mean that, the transformer remaining at work having a much lower primary impedance than the one with the open secondary, nearly all of the impressed e.m.f. of 2000 volts will be concentrated on the idle transformer and its primary will be destroyed. The proper precaution is to fuse the neutral lead so lightly that as soon as one of the main fuses blow, the neutral fuse will be also melted, throwing out both secondaries. Where the secondaries are connected in parallel, the proper precaution is to locate the transformer fuses beyond the junction of the secondary leads instead of fusing each secondary separately.

Hot Water Heating for Central Stations.

It "goes without saying," to use an anglicized French phrase, that all central-station men are on the alert for any means of increasing the net earnings of their plants. It is furthermore well known that one of the most widely-advocated methods of attempting this is to sell exhaust steam for heating purposes. The correlated plan of supplying hot water for the same need has not found so many supporters, nor have the possibilities of such a system been made the subject of much publicity. The paper read before the American Society of Mechanical Engineers by Mr. Yaryan, describing a hot-water heating system in Toledo, will, therefore, greatly interest many readers by reason of the astonishing results obtained with that system and discussed in the paper. The experience in Toledo is chiefly remarkable in that the receipts from the heating service paid over 93 per cent. of the total operating expenses during the last half of last year, leaving almost all of the receipts from the lighting service clear gain. Such a showing is very little short of ideal, and staggers one's credulity.

It is highly probable that the practicability of profitably selling heat distributed in this manner is restricted to cities of intermediate size. In towns and small cities the cost of installation would likely be disproportionate to the amount of patronage obtainable, and in very large ones the difficulties of installing and maintaining the underground system would be enormous. Mr. Yaryan points out that the failure in Boston of such an attempt twelve years ago was largely due to the high temperatures adopted and the correspondingly high rate of circulation realized, which caused excessive pipe friction. It is more than probable that these features were potent in the downfall of the scheme, but it is also known that the difficulty of maintaining the underground plant contributed in great measure to its abandonment. It is interesting to note in this connection Mr. Yaryan's statement to the effect that steel pipes become pitted and wrought-iron ones do not. It would have added to the value of the paper if the result of experience with cast-iron pipe could have been presented.

DESIGNS FOR SMALL MOTORS.—VIII.

TWO H.P., FOUR-POLAR MOTOR WITH TWO-PATH DRUM ARMATURE.

BY CECIL P. POOLE.

For the motor here described only one type of field magnet is shown, namely, the familiar ring yoke with radial magnet poles. A choice is given, however, between cast-iron and cast-steel. Fig. 1 shows the cast-iron magnet frame and Fig. 5 the cast-steel frame. Fig 3 is an edge view of either frame and Fig. 4 is a plan view. The cast-iron machine will be found easier to make because there is less tooling to be done and iron castings are smoother than steel, requiring little or no finishing elsewhere than the pedestal seats and pole faces.

The measurements for the cast-iron magnet are as follows:

	Ins.
A—Bore of armature chamber	7
B—Radius to which pedestal seat is bored	6⅝
C—Outer diameter of yoke ring	15⅝
D—Distance between parallel inner faces of yoke ring	12
E—Width of plane surface behind coil	6
F—Width of magnet core	3
F_2—Breadth of magnet core	4½
G—Distance from core to angle of yoke	1½
H—Width of frame foot	2½
H_2—Length of double foot	5
J—Width of pedestal lug and seat	3⅝
K—Length of pedestal lug; commutator side	6⅞
L—Length of pedestal lug; pulley side	3⅞
K—Length of pedestal seat	3⅝
M—Axial width of magnet yoke	8 7/16

Fig 2 shows the cross-section of a magnet core, from which it will be seen that the corners of the core are rounded off. The radius of the curve here is 0.3 in. The only machining that should be required for this frame is boring the armature chamber and pedestal seats and drilling 12 bolt-holes. The frame should be clamped to a lathe carriage with its center true with the lathe centers, and the boring done at one setting by means of a boring bar and tool. Both pedestal seats should be cut before the frame is moved from its original position.

The magnet must be made of the very best grade of iron obtainable; use Scotch pig if possible. It should be allowed to remain in the sand until it is cold, care being taken not to remove any of the sand around the magnet portion until the casting is ready to come out. The longer of the two lugs might advantageously be placed uppermost in putting the pattern in the sand, and after the casting has been cooling for 24 hours the sand may be scraped away from the end of this lug so that its temperature may be noted.

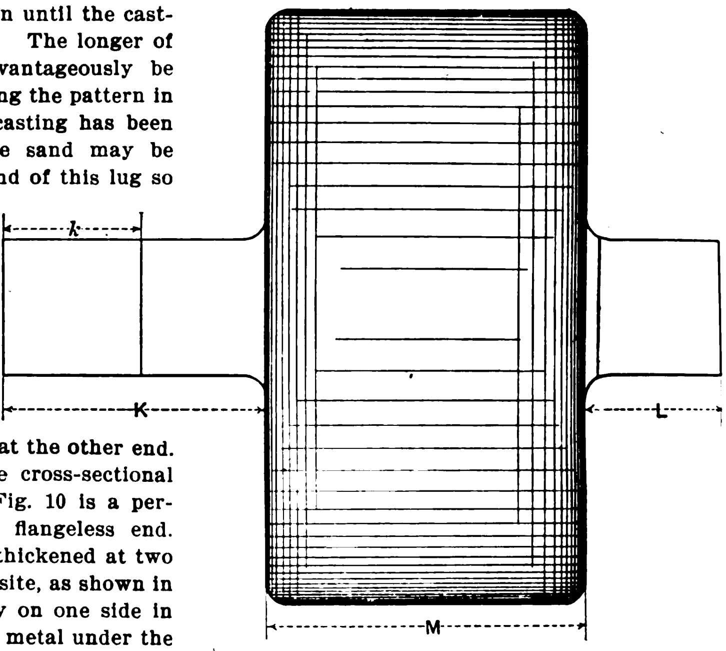


FIG. 4.—PLAN VIEW OF MAGNET.

Fig. 8 shows the shaft and a cross-sectional view of the armature core. The discs are mounted on a cast-iron drum, d, which has a flange, f, and a hub, h, at one end, and a hub, h, at the other end. Fig. 9 gives a transverse cross-sectional view of the drum, and Fig. 10 is a perspective view, from the flangeless end. The wall of the drum is thickened at two places, diametrically opposite, as shown in Fig. 9. This is necessary on one side in order to provide sufficient metal under the keyseat; it is necessary on the opposite side to obtain a mechanical balance.

The discs are held endwise by a clamping ring, r, which may be either screwed onto the end of the drum, d, or held on by four flat-headed screws with large heads. The discs are held from turning by a key. At each end of the magnetic core a disc of fibre, indicated by heavy black lines, should be placed. These discs must be exactly like the iron discs, except that they are 1/16 in. thick.

The iron core discs are 6⅞ ins. outside diameter and 1/40 in. thick, with 43 slots, each ¼ in. wide and 9/16 in. deep. The slots have parallel sides. The discs must be of the best charcoal iron; the hole in the center is 3⅝ ins. in diameter, keyseated. The flange, f, and the clamping-ring, r, must have their outer edges rounded off to avoid cutting the insulation of the winding. The dimensions of the core drum are as below:

	Ins.
Length of drum, d	5 1/16
Inner diameter of d	3
Outer diameter of d	3⅝
Diameter of flange, f, and ring, r	5¾
Thickness of flange, f, and ring, r	5/16
Thickness of d at thickest point	½
Diameter of hubs, h and h_2	2
Bore of hubs, h and h_2	1¼
Length of hub, h	1½
Length of hub, h_2	1¼
Length, a, of disc portion of core	4¾

The shaft measurements are as follows:

At	v	x	y	z
Diameter, inches	¾	1	1¼	¾
Length, inches	3⅝	3	9	7¼

The shoulders where v and x meet and where y and z meet should be slightly rounded off at the corner and filleted in the angle. A key should be used to fasten each hub to the shaft, but the machine will doubtless give satisfaction with only

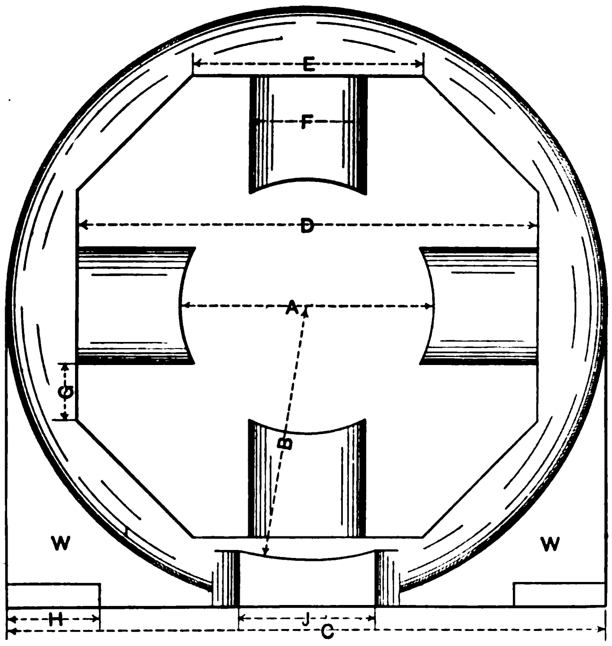
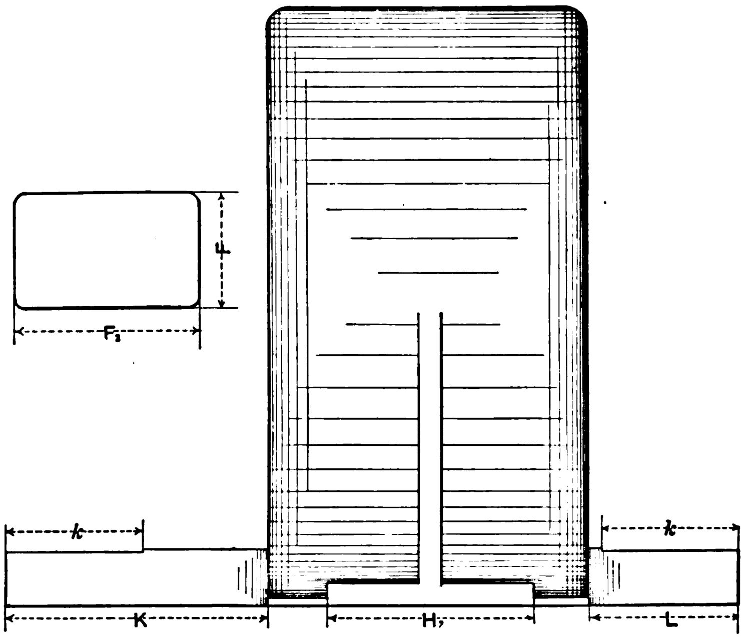


FIG. 1.—CAST-IRON FIELD MAGNET.



FIGS. 2 AND 3.—FIELD MAGNET.

one key, that one being in the hub, h, at the pulley end. The hub, h, must be exactly ¼ in. from the shoulder on the shaft.

Figs. 11 to 14, inclusive, show end and side views and cross-sections of a journal pedestal and box. The two bearings are alike in every particular, and are made of cast-iron. The base or foot is tooled to conform to the circle to which the pedestal seat, on the magnet frame, is machined, and is ⅝ in. thick. The standard or pedestal consists of two ribs at right angles to each other, ⅝ in. thick and having curved edges, as shown. The box is of the ring-oiling type, with a single ring hung about midway of the journal; the bushing is easily made from thin brass tubing, 1 in. outside diameter, and with a very thin wall (not over 1/32d in.), babbitted to fit the shaft and having a slot 7/16 in. wide cut half way through it, nearly midway between its ends; accurately, the slot must be ¼ in. nearer one end than the other. The bushing is 3⅝ ins. long; the oil ring is made of brass, 2 ins. in diameter, inside, 2¼ ins. diameter outside, and ⅜ in. wide along the shaft. Reference to the side views of the journal pedestal will show a slot in the upper wall of the box portion, through which the oil ring is inserted before putting in the bushing. A cover should be provided for this slot to keep out dust, etc. The dimensions of the journal pedestals are as follows:

	Ins.
B—Radius of arc. pedestal seat	6
g—Length of circular oil reservoir	2
i—Length of journal box	3⅝
Bore of jornal box	1
j—Diameter of oil reservoir	2⅞
Internal diameter of oil reservoir	2½
J—Width of pedestal foot	3⅝
k—Length of pedestal foot	3⅝

The bore of the box portion of the pedestal must, of course, be made to fit snugly the outer diameter of the tubing used for a bushing, as the wall of the latter is too thin to admit of turning it down to fit a predetermined bore in the pedestal. After boring the pedestal to fit the bushing it should be mounted on a mandrel and its base turned to the radius B, of 6 ins., which is the same as the radius of the circle of the foot on the magnet frame. Each pedestal should be fastened to the foot with four 5/16-in. cap screws.

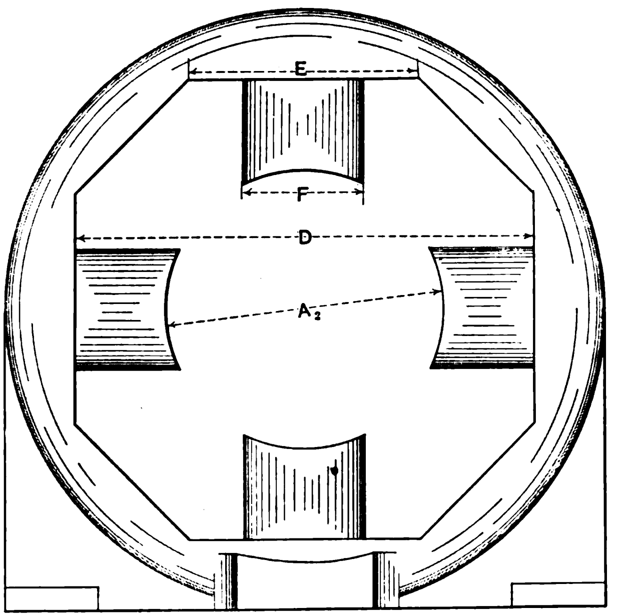


FIG. 5.—CAST-STEEL FIELD MAGNET.

Of the two field magnets shown, the steel one is much preferable if the reader has the skill and facilities to make it properly. The difference from the cast-iron magnet consists in making the magnet cores round instead of oblong, and putting on pole-shoes. The length of the machine is thereby reduced 1¼ ins., but all the transverse measurements remain unchanged. The magnet ends are machined exactly as in the case of the cast-iron frame, but the bore, A_2, is greater, namely, 7½ ins.

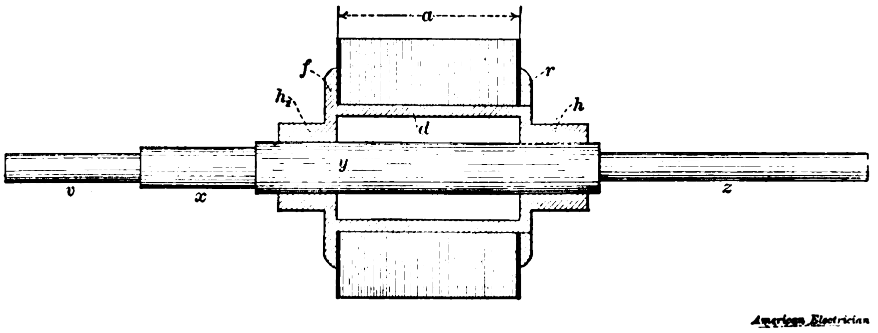


FIG. 8.—ARMATURE CORE AND SHAFT.

The pole-pieces are made in one piece, called a polar-bushing, like Fig. 6, and this had better be done before the magnet is bored out. This bushing is a simple cylinder of cast-iron with four openings in its wall, equidistant from each other. Fig. 7 shows the exact shape of each of these openings. The measurements of the bushing are these:

	Ins.
A_2—Diameter of bushing, finished	7½
A—Bore of bushing, finished	7
a_2—Length of bushing, finished	3¾
b—Length of openings in wall	3½
c—Radius of curve, side of opening	4½
e—Maximum width of opening	2½

The casting for this bushing should be about 4 ins. long, 7¾ ins. in diameter and 6¾ ins. bore, in the rough. After it has been turned down to the finished diameter, mount the magnet frame and bore out its polar circle to such a size that the bushing is a snug fit—not quite a driving fit, but tight enough to prevent turning by hand. Then insert the bushing so that the openings in its sides come half way between the magnet cores, and scribe the outlines of two opposite cores on its surface.

Remove the bushing and set a steel pin at each extremity of each ellipse scribed on the surface. Then put the bushing back and bore it out for the armature chamber. The pins will take up against the edges of the magnet cores and prevent the bushing from turning. After boring it out, turn off the ends of the bushing so as to leave the connecting webs from pole-piece to pole-piece ⅛ in. thick, measured axially.

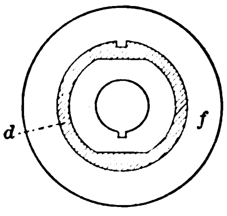


FIG. 9.

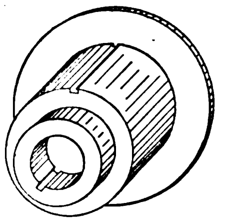
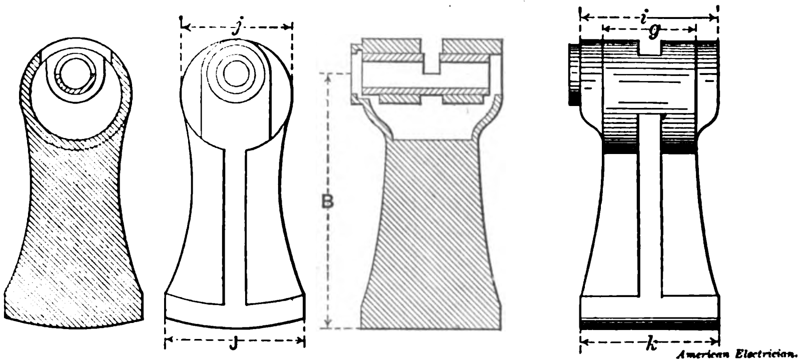


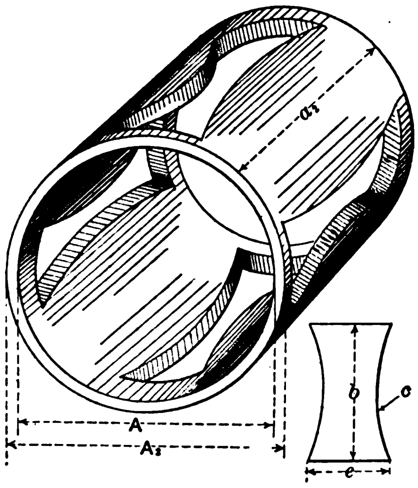
FIG. 10.

The objection to this magnet is the difficulty of fitting the bushing to the magnet with sufficient accuracy to make good magnetic contact and still leave it loose enough to permit removal without breaking the thin connecting webs. This could be obviated by bolting the pole-pieces to



FIGS. 11 TO 14.—JOURNAL BOX AND PEDESTAL.

the ends of the magnet cores by means of long, slender machine screws, put in from the outside of the yoke through holes in the centers of the magnet cores. Then the connecting webs could be sawed out entirely, leaving each pole-shoe independent of the others. This construction is also magnetically preferable, and if the builder has means for drilling ¼-in. holes through the magnet cores from the outside of the yoke ring to the inside of the bushing (a distance of 4⅜ ins.), the pole-shoes should be held on this way.



FIGS. 6 AND 7.

With the steel magnet the following measurements must be substituted for those previously given:

	Ins.
F—Diameter of magnet core	2⅞
M—Width of magnet yoke	7 3/16
a—Length of disc part of core	8½
Length of drum, d	3 13/16
Length of y, on shaft	7¾

This is to say, the machine must be exactly 1¼ ins. shorter, axially.

The four field coils for the cast-iron magnet frame are of No. 22 single-cotton-covered magnet wire. The depth of the winding must be 1½ ins., as nearly as possible, and the length along the core should be 2¼ ins. Careful and close winding should give 50 layers of wire, with 70 turns to a layer. Whatever number of turns the reader may obtain, that number must be precisely the same in all four coils. In order to attain uniformity the coils should be wound upon a frame and the turns religiously counted.

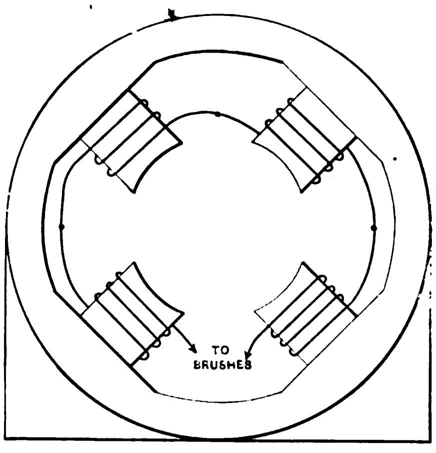


FIG. 15.—CONNECTIONS OF FIELD COILS.

A winding frame for such a purpose was described in connection with the motor design published in the American Electrician for January, 1899. In this same article full instructions for securing the ends of the coil and insulating it with tape were also given. It will be found advantageous to tie a knot in the starting end of each coil before taping it so that it may be identified afterward. The coils must be connected up as shown by the diagram, Fig. 15, so that the starting end of one connects to the finishing end of its neighbor. This presupposes that all four are wound in the same direction, as they should be.

The coils for the cast-steel magnet are of No. 23 single-cotton-covered wire, 1½ ins. deep and 2 ins. long. Good winding will enable the reader to put on 56 layers of wire and 70 turns to a layer. As in the previous case, however, the depth in inches is the essential point, though it is advantageous to get as many layers in that depth as possible. The coils are, of course, wound, insulated and connected up exactly like the oblong coils of the cast-iron frame.

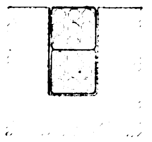


FIG. 16 —ARRANGEMENT OF WIRES IN A SLOT.

The armature core for either of the magnet frames will contain 43 coils; each coil consists of No. 16 double-cotton-covered wire, wound three turns wide by three layers deep. Each slot contains one side of each of two coils, so that the cross-section of the winding in a slot will be as in Fig. 16.

All armature coils should be wound on a forming bobbin so that they will all be exactly alike. Fig. 17 shows what the essential dimensions should be. The width of the hollow of the coil is the same for both armature cores. As the armature core to be used with the steel magnet is 1¼ ins. shorter than the other one, the coils for this core must be correspondingly shorter; hence the two dimensions for coil lengths.

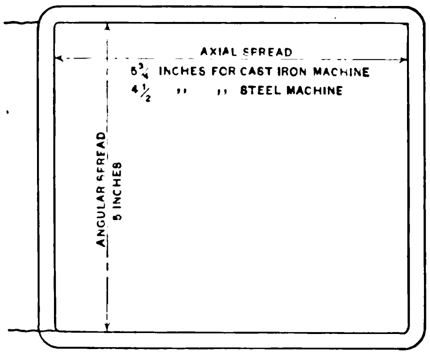


FIG. 17.—SHAPE OF AN ARMATURE COIL.

Fig. 19 is a winding diagram and shows four coils in position. The coils are indicated by single lines across the head and dots in the slots for simplicity. The builder should note that the left-hand side of each coil is in the bottom of the slot and the right-hand side is on top; this should be true of every coil, but it is not imperative. The machine will work just as well if half of the coils are put on with both sides bottom and the other half on top of them, but the job will not be so neat on the armature heads. The spacing or pitch of the coils must be exactly as indicated—10 slots in between the two sides of each coil.

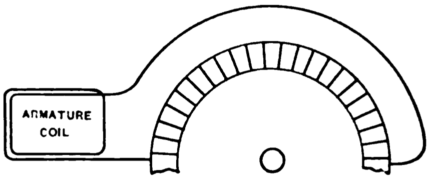


FIG. 18.—COIL CONNECTED TO COMMUTATOR

The starting ends should be knotted for identification, and all the knotted ends should occupy the same relative position on the core. If put in properly, the coils will give a regular sequence of knotted ends and straight ends, one each projecting from each slot. The connections to the commutator are then simple. Carry all the knotted ends straight out to the commutator, and each straight end to a segment 22 bars from the one to which the knotted end is connected. Fig. 18 represents one coil connected, and shows that there are 21 segments between the two to which the coil ends go, reckoning around that side of the commutator nearest the coil itself. This spacing must be observed throughout.

The commutator must have 43 segments and should be purchased already built for assured satisfaction. The brush surface of the commutator must be 1½ ins. long, at least, so that carbon brushes 1¼ ins. wide and ⅜ ins. thick can be used. The diameter of the barrel of the commutator should not be less than 4, and preferably 5 ins. The brush holders and yoke may be copied advantageously from any of the standard machines now on the market. Only two brushes are to be used, and these set precisely a quarter of a circle apart, reckoning around the barrel of the commutator.

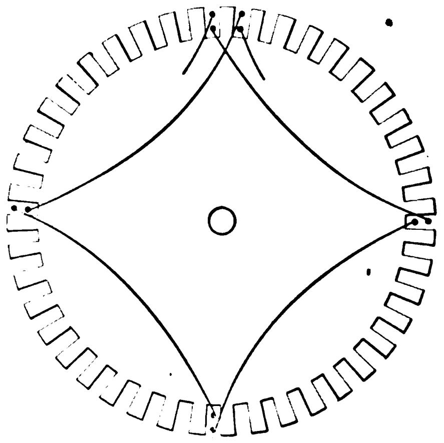


FIG 19.—FOUR ARMATURE COILS IN POSITION.

The windings just described are for machines to work on a 110-115-volt circuit. If windings for 220-230 volts are desired the armature coils should be of No. 19 wire, each coil five layers deep and four turns wide, making ten layers of wire per slot. The field coils of the cast-iron magnet must be of No. 26 s.c.c. wire, wound to the dimensions specified above, namely, 1½ ins. deep and 2¼ ins. long. The coils for the cast-steel magnet will be of No. 27 wire wound to a depth of 1½ ins. and a length of 2 ins. For 500-volt service use No. 23 double-cotton-covered wire on the armature, six turns wide and seven layers deep, per coil; 84 wires per slot. On the cast-iron magnet use No. 29 double-covered wire and on the steel magnet No. 30.

The principal magnetic and electrical data of the two machines are below:

115-Volt Motor.

	Cast Iron.	Cast Steel.
Res. arm. winding.....	1 ohm	0.9
Normal arm. current	18 amp.	18 amp.
Approximate speed....	1325 r. p. m.	1325 r. p. m
Flux per pole...........	340,000 lines	
Density in field cores.	33,700	70,000
Density in air gap...	26,000	38,000

No design for a starting rheostat has been given because the reader can buy a modern rheostat with no-current and over-load release for about the same money that materials for a home-made starting box would cost, and there is no comparison between the merits of the market apparatus and the home-made one.

STARTING RHEOSTATS FOR SHUNT MOTORS.

BY H. H. CUTLER.

The writer has read with a great deal of interest in the portion of the American Electrician Electrical Catechism relative to the electric motor and its control, beginning in the August issue of last year; this subject has been covered admirably, but there are several important points which have not been brought out, and which the writer has thought might be of general interest to readers engaged in motor work.

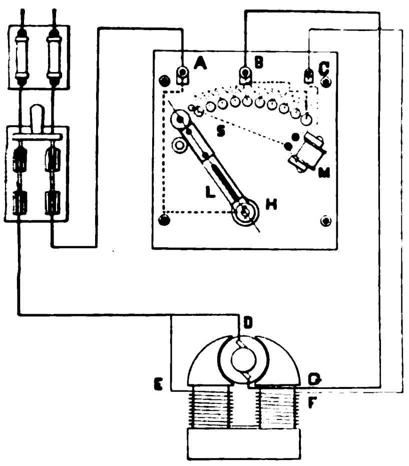


FIG. 1.

In the November, 1899, instalment of the catechism the method described of starting a shunt motor is the one usually laid down in the text books, and also the one practiced by one of the largest companies in the electrical business in this country. The writer believes, however, that this method is not only opposed to good engineering but is not general practice. As the catechism points out, the opening of the field circuit causes an induced current of very high potential, which is liable to pierce the insulation of the field-magnet coil. It has been the writer's practice for the past five years to provide for handling this shunt-field discharge in starting rheostats and other types of motor controllers, as follows: Instead of closing the circuit to the shunt field by means of the usual double-pole switch, this circuit is kept open until the rheostat lever is moved from its open-circuit position to the first live button. The effect of this is to fully energize the field by connecting it directly across the line, compelling the armature current, however, to pass through the resistance of the starting rheostat.

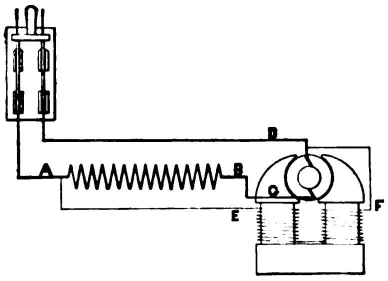


FIG. 2.

Fig. 1 shows a wire leading from the first live segment or button of the starting rheostat directly to the retaining magnet, and a connection from there through the field winding to the opposite side of the line. When the lever of the starting rheostat is moved to the second or third segment the field current is compelled to back up through a portion of the resistance of the starter. As the motor, however, has usually started by this time, sufficient c.e.m.f. has been induced in the armature winding to compel practically full magnetization of the motor fields, less the very small drop due to the ohmic resistance of the part of the rheostat that is included in the field circuit. Theoretically, this ohmic resistance will reduce the strength of the shunt field; practically, the reduction of strength is so small as to be negligible. When all the resistance of the rheostat is cut out, an extra contact is made which short circuits the resistance in the field circuit, thus giving absolutely full field strength. Fig. 2 shows the electrical relations of the various circuits more clearly.

A motor-starting rheostat connected in this way possesses many advantages which might not appear at first sight. In the first place the shunt-field circuit is permanently connected across the terminals of the armature so that it always has this circuit to discharge into, removing all tendency to puncture the insulation of the field coil on opening the circuit. Another feature peculiar to this method of connection is the fact that it makes it possible to open the circuit of an overloaded motor with absolutely no spark. This is true, however, only when the motor is running at full speed. The cause of this, of course, is the fact that when a motor is running at full speed the c.e.m.f. of its armature is only slightly less than the e.m.f. of the line supplying the motor; the small difference between the two is insufficient to cause an arc when the main circuit is opened. It is possible at any time to open the double-pole knife switch connecting the motor to the lines and close it again so quickly that the motor will not show that anything has happened, and this can be done with practically no sparking. With a motor starter of the kind described, the first thing which occurs when the motor is overloaded is the short circuiting of the retaining magnet; the rheostat lever then flies back and inserts all the resistance in series with the armature and finally opens the circuit without any appreciable sparking.

The feature alluded to above can be very simply illustrated by the following experiment with such a starting box: Move the lever to the first live segment and then pull it back again as quickly as possible; a very heavy flash will result. Next move the lever to the first contact and hold it there until the motor starts, and then pull the lever back. Scarcely any spark will then occur. The only reason I have ever heard advocated for energizing the field of a shunt-wound motor before closing the armature circuit is that it takes a little time to energize the field magnet. This is another case of a correct theory wrongly applied. The time required to energize the field magnet of an ordinary motor is so small as to be utterly negligible in this connection, so that it is seldom necessary to close the field circuit before closing the armature circuit.

Another source of frequent complaint as to motor-starting boxes is the lack of care or comprehension as to the connections between the motor and the rheostat. Installation men frequently interchange the heavy wires leading to the starting box, with the result that the armature. when standing still, practically short circuits the field winding, so that it is impossible to energize the field and enable the motor to start. Fig. 3 is a diagram showing a starting rheostat wrongly connected, and Fig. 4 shows the circuit relations result-

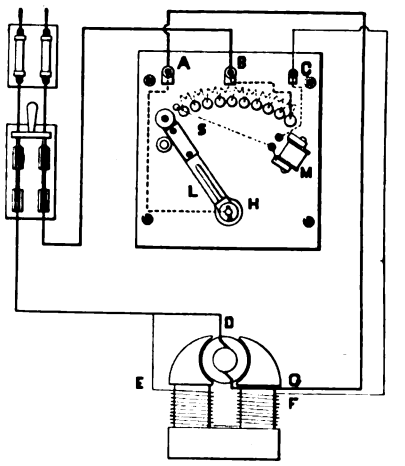


FIG. 3.

ing. It will be seen by reference to these diagrams that the current for the shunt field, as well as that for the armature, passes first through all the resistance of the starting rheostat. The entire drop in voltage, due to the insertion of this resistance, thus affects the field as well as the armature, and it is consequently impossible to start the motor.

A case which serves to illustrate this point came within the writer's observation a few weeks ago. A travelling company had sold tickets for a show in which a motor equipped with a plain speed regulator having but two binding posts was a vital factor. In wiring up this regulator they connected the shunt field of the motor in series with the resistance of the rheostat. Of course the motor would not start. They called in six electricians in that city, all of whom said something was the matter with the rheostat. The result was that they were obliged to give up the show and refund over a thousand dollars to a disgusted would-be audience.

Another point which does not appear to be thoroughly understood by users and sellers of motors, is the question of abnormal starting current. One of the first principles in mechanics is the proposition that it always takes more power to start a load from standstill than it does to keep it moving. The load on an electric motor is no exception to this law. The chief use of a motor-starting rheostat is to start the motor, as its name implies, and it should be designed with regard to the current required for this purpose, not the current required to operate the motor at full speed. This point probably comes out most prominently in the application of electric motors to elevators.

Many people figure the horse-power required to operate an electric elevator by adding the weight of the car to the weight to be lifted, subtracting the weight of the counterbalance, and take the result as the number of pounds to be lifted; they then multiply this by the number of feet per minute at which it is desired to run the car, and take this second result as the foot-pounds of work per minute to be performed by the motor. They then allow an arbitrary margin for loss in gearing, efficiency of the motor, and other well-known losses, and take this figure as the horse-power of the motor required. Insufficient attention is thus given to the fact that an elevator's chief duty is to start and stop, and that the amount of current required to lift the load after it has got started has little to do with the case. An elevator will frequently operate with no current whatever, after the car has been started, because of the excess of weight in the counterbalance.

The same trouble also occurs to a less extent in connection with printing presses. Machines of this character have a large number of gears and moving parts, and frequently require from two to three times as much power to start them as to operate them. Engineers frequently overlook this fact and install a motor of sufficient size to operate the press at full speed, but do not provide this motor either with sufficient torque to be capable of continuously starting and stopping the press, or with controllers large enough to do the work. To claim that a motor is large enough to do its work because it runs all right after its load is started is very much like claiming that one horse is sufficient to haul a wagon carrying four tons of coal because if one could only give a shove vigorous enough to start him off he could easily keep going on level ground.

Of course due allowance should be made of the ability of continuous-current motors to stand temporary overloads in starting, but it should not be forgotten that a larger motor will start a given load with less current when the current required is within the rated capacity of the motor than would be the case with a smaller motor overloaded at the start. In printing work the press has to be continually started and stopped during the "make-ready" period, and the rush of current necessary for large presses is very objectionable. For this class of work the use of double-commutator motors would be good practice; the use of an auxiliary series field of low carrying capacity, which is cut out after the motor starts, would be another excellent way of cutting down the abnormal starting current.

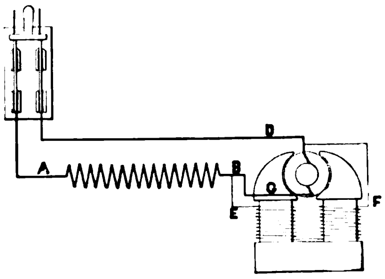


FIG. 4.

In standardizing motor-starting rheostats, the writer has made a practice of stamping each rheostat with the motor current in amperes at a certain number of volts, the device being designed to start a motor whose starting current will not exceed the amount stamped upon the name plate. The writer also makes it a rule to caution motor users to specify larger rheostats whenever abnormal starting currents are liable to occur.

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SOME POINTS ABOUT INDUCTION MOTORS.

BY W. T. MORRISON.

It is well known that induction motors do not run at constant speed, but vary according to the load, the rate of rotation decreasing as the load increases. The speed of the motor as indicated by the name plate is the no-load speed, which is in synchronism with the alternator. For this reason induction motors have been used to take the speed on an alternator at a distance, a tachometer connected to the shaft of the motor being so light a load as not to affect its speed appreciably. The drop in speed at full load on large motors (50 h.p. or over) is so slight that it is hardly noticeable. For smaller motors the drop in speed varies from 5 per cent. to 10 per cent., depending on size, design, etc.

The following facts as to current, etc., will act as a general guide to what can be expected of these motors. Full-load currents for small 110-volt three-phase motors, say one to four horse-power output, is usually six amperes per horse power per phase. The current per leg of a two-phase motor is about 87 per cent. of the current per leg of a three-phase motor of identical output, voltage, efficiency and power factor. For a single-phase motor the current would be 1.73 times the three-phase current per leg. Motors of medium size (4 to 50 h.p.) take about 5.6 amperes, and large motors (75 h.p. and upward) about 5.2 amperes in each leg per horse power per 110 volts. The current for other potentials varies inversely as the voltage. The current running light is usually 25 to 30 per cent. of the full-load current. For motors of 20 to 30 h.p. the apparent efficiency is about 80 per cent. and the power factor is about .90. Motors of 75 to 100 h.p. have an efficiency of 90 per cent. and a power factor of .85 to .90. The power factor on two-phase elevator motors of 5 to 10 h.p. was found to be about .70 at starting. The indicated intake in one phase on starting was found to be 5.5 kw.; the test on this motor was not as accurate as the tabulated tests mentioned below, and must not be depended on except as an approximation.

Table I gives the current taken by single-phase motors at 100 volts and for various efficiencies and power factors. Tables II and III of tests practically explain themselves. The maximum horse-power output of an induction motor is reached at the point where the product of the speed × the torque is maximum. The torque of the motor increases with the load, up to a certain point near synchronism, beyond which it falls rapidly to zero; the speed decreases as the load increases, but not as rapidly as the torque increases, so that the product of the two increases constantly up to a point just beyond where the torque

TABLE I.

Showing the current required by 100-volt single-phase alternating current motors per horse-power of out put.

The current per phase of a 2-phase motor is ½ this value.

The current per phase of a 3-phase motor is 0.577 of this value.

A 200-volt motor requires ½ the current, and a 400-volt motor ¼ the current given by the table.

Efficiency.	Power Factor of the Motor.								
	.80	.82	.84	.85	.86	.87	.88	.89	.90
75%	12.43	12.13	11.84	11.70	11.57	11.43	11.30	11.18	11.05
76%	12.26	11.96	11.68	11.54	11.40	11.27	11.14	11.02	10.90
77%	12.10	11.80	11.52	11.38	11.25	11.12	11.	10.87	10.75
78%	11.95	11.66	11.38	11.24	11.11	10.99	10.86	10.74	10.62
79%	11.80	11.51	11.24	11.11	10.98	10.85	10.73	10.61	10.49
80%	11.65	11.36	11.09	10.96	10.83	10.71	10.59	10.47	10.35
81%	11.51	11.23	10.96	10.83	10.71	10.58	10.46	10.34	10.23
82%	11.37	11.09	10.83	10.70	10.58	10.46	10.34	10.22	10.11
83%	11.22	10.95	10.68	10.56	10.44	10.32	10.20	10.09	9.97
84%	11.10	10.83	10.57	10.44	10.32	10.20	10.09	9.97	9.86
85%	10.96	10.69	10.44	10.31	10.19	10.08	9.96	9.85	9.74
86%	10.83	10.57	10.33	10.20	10.08	9.96	9.85	9.74	9.63
87%	10.71	10.45	10.20	10.08	9.96	9.85	9.74	9.63	9.52
88%	10.60	10.34	10.09	9.97	9.86	9.74	9.63	9.53	9.42
89%	10.47	10.22	9.97	9.86	9.74	9.63	9.52	9.41	9.31
90%	10.36	10.11	9.87	9.75	9.64	9.53	9.42	9.31	9.21

begins to fall off. This point is the point of maximum output. A motor cannot be worked at this maximum output because of the excessive heating, and it is risky to keep a small motor up to that output even long enough to take speed and current measurements. The "break-down" load of an induction motor is practically identical with the maximum output and is dependent upon the number of turns in the field and the voltage. It varies inversely as the square of the number of turns and directly as the square of the voltage. It is also slightly less, as might naturally be supposed, when the motor is hot. The standstill current in the tables is the instantaneous starting current at the different steps of the starting switch and was taken with the rotor blocked; 1 is with all resistance in; 2, with part cut out, and 3 with all resistance cut out.

The tables show that for ordinary induction motors, the current taken at maximum output is about twice the full-load current, and the standstill current, with no resistance in the armature circuit, is about three times the full-load current. With resistance in the armature circuit the starting torque and starting current are equal, and about 150 per cent. of full load. The maximum overload output is from 1.5 to two times the rated horse-power of the motor.

TABLE II.
Current taken by single-phase motors under test, February 19, 1900.

		2½ h.p. 60 cycles, 110 volts.	4 h.p. 125 cycles, 104 volts.	15 h.p. 125 cycles, 104 volts.
At maximum output in h. p.		3.84	6.2	19.8
At maximum current.......		62	115	310
Current at normal load.....		34	62	190
" running light.......		21.8	38	75
Per cent drop in speed.		6	4	3.75
Standstill current	1.	105	37	198
	2..	......	55	376
	3....	......	150	474

The power factor when running free, or with no appreciable load, is from 10 to 15 per cent. Tests on a 5-h.p. motor, with resistance in the armature and with short-circuiting switch, gave exceptionally good results, the power factor being .85 and the apparent efficiency .72. Motors of this type are more efficient than ordinary elevator motors which have separate starting resistance. The armature resistance in such motors is increased to increase their starting torque, but this decreases the running efficiency and also causes a greater drop in speed. For this reason the power factor of 85 per cent. and the apparent efficiency of 72 per cent. are probably above the average for motors of this size. The true efficiency can, of course, be obtained by dividing the apparent efficiency of the power factor, which, in this case, gives 85 per cent. At three-fifths load the efficiency of the 5-h.p. motor increased one per cent. and the power factor dropped two per cent.; at one-fifth load the efficiency was 60 per cent. and power factor 65 per cent.

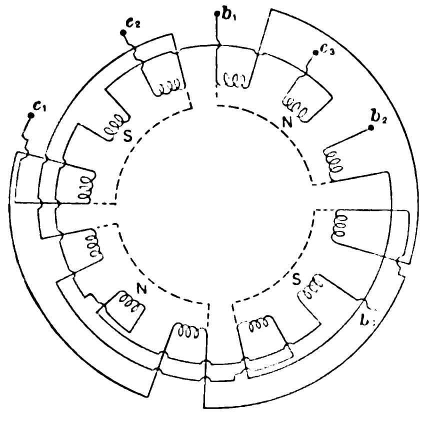


FIG 2.—4-POLE STATOR DIAGRAM.

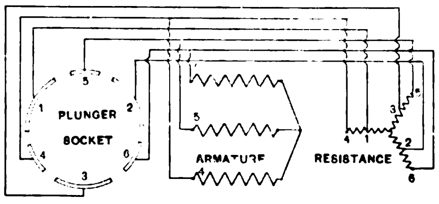


FIG. 1.—THREE-PHASE STARTING SWITCH.

TABLE III.
Current taken by induction motors under test, February 19, 1900.

		1 h.p.		5 h.p.				10 h.p.		20 h.p.		75 h.p.	
		125 cycles, 104 volts.		60 cycles, 220 volts.		50 cycles, 500 volts, 3-phase	50 cycles, 500 volts, 3 phase.	60 cycles, 220 volts.		60 cycles, 550 volts.		66.75 cycles, 550 volts, 2-phase.	60 cycles, 550 volts, 3 phase.
		Single phase.	3-phase.	2-phase.	3-phase.			2-phase.	3-phase.	2-phase.	3-phase.		
Maximum output in h.p......		1.4	1.57	8.5	8.4	9.3	7.5	13.8	13.5	35.2	30	120	120
" current..........		29.5	15.5	26	28	15	14	55	60	40	42.5	150	160
Current, normal load		19	8.3	12	13.6	5.4	5.8	25	30	20	24.4	76	78
" running light.........		12.4	2.6	4.9	4.5	2.2	2.2	7	8.9	10	8.2	31	29
Per cent drop in speed.........		7.6	7.5	6.6	4.1	3.76	8	5.8	5	3.3		3.4	3.5
Standstill current	1	43.5	25.5	44	10.8	9	22.4	39	43	44	36.6	127.5	126
	2	...	......	......	20.2	19.7	......	54	53	76	63.6	188.5	240
	3...	....	......	...	52.6	.....	...	69	73	88	74	213	250
....		......	....	...	......	......		78	88	......	......	....	.....

On motors of moderate size, in which starting resistances are used, the resistance coils and switch are mounted on the rotor shaft in the space within the core of the rotor. Fig. 1 represents the connections between the starting resistance and the winding of a three-phase circuit, together with part of the switch contacts, the latter being numbered from 1 to 6. The switch consists of a simple plunger arranged to slide along the shaft and enter a socket or chamber formed by six contact strips, as shown in the illustration. The movement of the plunger is controlled by a hand lever external to the motor, the motion of which is transmitted to the plunger through the medium of a grooved collar sliding on the shaft. The contact clips, 1, 2 and 3, project upward twice as far as the clips, 4, 5 and 6. At starting, the plunger is not in contact with any of the clips, and all of the resistance is therefore in circuit; as the motor gains speed the plunger is pushed inward until it enters the clips, 1, 2 and 3, in which position half of the resistance is cut out. A further movement inward causes the plunger to connect the clips, 4, 5 and 6, cutting out all the resistance from the armature circuit. In operating a switch of this type the plunger should be thrown in with a quick positive movement in order to prevent any uncertainty of contact and sparking between the clips and the end of the plunger.

A few centrifugal-switch motors have been built. The switch that cuts out the starting resistance is mounted on the armature shaft, like the one just mentioned, but it is operated by a centrifugal governor mechanism. The object is to allow one to start up a motor at a distance, the circuit being closed there and the motor taking care of itself by means of the centrifugal switch. In the special cases for which some of the first of this class were designed, the intake of the motor equalled practically the output of the generator, and as the motor had to run at full-load torque from the start, it was imperative that the switch should work well. The device comprised a fly-ball governor, which actuated one switch to cut out part of the resistance when the armature attained a certain speed, and another switch to cut out the remainder of the resistance when it almost reached full speed. It was found that the motor was quite sensitive, and if either switch failed to work at the proper time, the motor would drop speed and fail to carry the load.

Fig. 2 is a winding diagram of a four-pole three-phase stator, and Fig. 3 a similar diagram for eight poles. The field coils are connected up to form the three separate phases, indicated by the figures, 1, 2 and 3, and the three groups are then connected in Y or delta to the headboard terminals. The letters indicate the beginning and ending of the phases, b indicating the beginning, and e the ending,

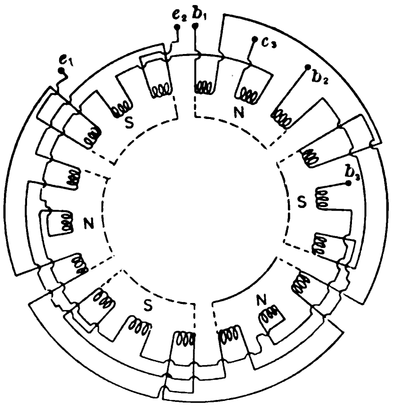


FIG 3.—8-POLE STATOR DIAGRAM.

and the figures serve to identify the phases. In both the diagrams shown, all poles are connected in series, but this is not always the case. Fig. 4 is a winding diagram of a four-pole two-phase stator, which is self-explanatory.

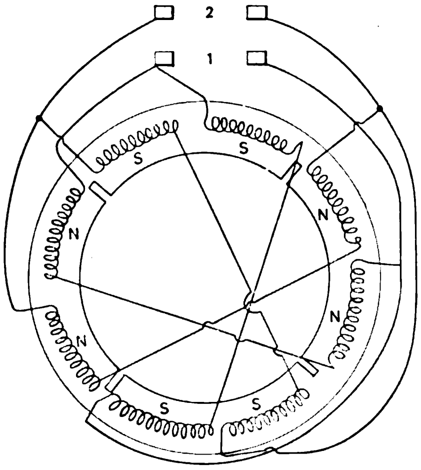


FIG. 4.—TWO-PHASE FOUR-POLE STATOR.

The armature conductors of an induction motor are often grounded to the frame through the armature core. One armature was returned by the purchaser, who supposed this to be a radical defect.

A three-phase induction motor is often used as a single-phase machine. If the impressed voltage on a three-phase motor is raised 30 per cent. and the machine run single phase, it would then break down at 75 per cent. of its former three-phase break-down load. A 1-h.p. 85-volt three-phase motor ordinarily takes about 8 amperes per leg at full load. The same size 110-volt single-phase motor takes about 16 amperes; hence a three-phase 1.3-h.p. motor, designed for 85 volts, with a break-down of 2 h.p., will be a 1-h.p. single-phase 110-volt motor having a maximum output of 1.5 h.p.

Motors in which bearing and end plate are in one piece are advantageous mechanically in that it is only necessary to turn the shields through 180 degrees in order to invert the motor and hang it from the ceiling, as is usually done in cotton mills. The induction motor is especially well suited for cotton mill work because the speed is practically constant and the load fairly so. Cases are on record in which cotton mill motors have run entirely enclosed under full load for 10 hours with excessive temperature increase.

Hoist motors for mine work are provided with a rheostat in the armature circuit for small sizes, and a rotary converter oil switch for very large ones of several hundred horse-power. The resistances for the armature circuit of the latter are made up of iron grids mounted on slate panels about five feet high and three feet wide, and flexible cords run from the switch to the panels. On the smaller class of hoist motors there are three levers, one to throw on the current, the second to throw in the friction clutch of the drum, and the third to control a brake.

PHOTOMETRY FOR CENTRAL STATIONS.—II.

BY LYMAN C. REED.

Assuming that a commercial photometer, such as one of those described in the last chapter, has been selected,'in which the standard is an incandescent lamp, the arrangement of the circuits for testing may be made in several ways, three of which are given. (1) A separate circuit for each lamp. (2) The same circuit for both lamps, with equalizer. (3) A three-wire circuit fed by a small storage battery. These three methods all assume that the secondary standard is a properly aged and tested incandescent lamp obtained from some reliable laboratory.

The first method, in which a separate circuit is employed for each lamp is roughly illustrated by Fig. 5, where A is the lamp to be tested in the rotating socket, and B is the standard lamp. Both lamps are fed from a common two-wire service, C, D. This is preferable to feeding the lamp from a three-wire service, as the fluctuation in voltage on either side of such a circuit may not be of the same period or amount and thus cause an unevenness in the intensity of either light which is avoided by using a two-wire service. Variable resistances, E and F, are connected in series with each lamp respectively and so constructed that a small movement of the slidable contact produces only a slight variation in resistance. A common form of such resistance is a cylinder of insulating material wrapped spirally with bare resistance wire over which slides a contact ring.

In series with the lamp, A, is placed an ammeter, Am, and a voltmeter, Vm, is so arranged that by means of a double-throw switch it can be connected to the terminals of either lamp. The voltmeter and ammeter are not essential if a mere comparison of light intensity is made, as any fluctuation in the service e.m.f. affects both lamps alike, but if a wattage test is conducted at the same time, the two instruments are indispensable. The ammeter reading multiplied by the voltmeter reading gives the watt reading, but if the voltage is fairly steady, a close approximation of the wattage may be had by simply observing the ammeter and getting the watt values from a previously prepared table.

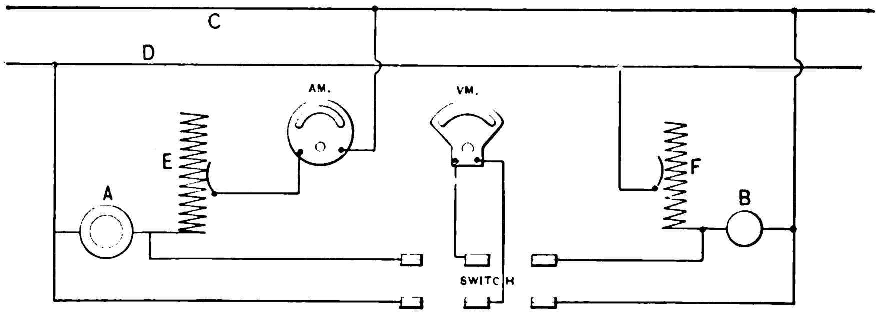


FIG. 1.—DIAGRAM OF PHOTOMETER CONNECTIONS.

If the service is taken from the street mains and the lamps to be tested are for service on these mains, the standard at B should be of a lower voltage and the variable resistance should be adjusted to give this lamp the voltage at which it should burn. If a wattage test is made on the lamps, it is extremely annoying to have the voltage remain below the normal for any length of time, and for this reason it is best to have the service come directly from the bus-bars in the station and adjust the voltage at lamps to the proper value by means of the variable resistances. The voltage at the bus-bars should be kept very steady and the resistances in series with the lamps after once adjusted should need little attention. If a wattage test is made on each lamp the voltmeter and ammeter are left in circuit with the lamp being tested.

In this connection of lamps a removal of the lamp, A, only causes a rise in potential at B equal to the drop on the wires, C, D, caused by the current consumed by A, hence the voltage of the standard, B, is practically unaffected by the removal of A. In testing a number of lamps, however, it is found that they will vary considerably in current consumed and this fact, owing to the variable drop caused thereby in the resistance, E, makes the lamp at A burn at a different relative voltage to B unless the resistance, E, is constantly varied to suit each lamp tested. Therefore, when a comparison is made an error is introduced unless the resistance, E, is changed to give the same relative voltage across A that B receives. To do this, two voltmeter readings have to be taken and in the mean time the voltage on C, D may have varied, vitiating the results.

A way of overcoming this trouble is shown in Fig. 6, where the same methods of connection are used, but an equalizing wire connected between E and F places the resistances in parallel when the two lamps are in circuit. This connection is to be broken when A is removed from its socket. For convenience the breaking of the equalizer connection is so arranged in practice as to be accomplished by the same operation that removes the lamp, A, from its socket. The voltmeter is connected to the equalizer wire and the wire, C, and indicates the common voltage on both lamps. The wattage of the lamp, A, is the product of the ammeter reading and the voltmeter reading when the equalizer is closed. In both of these first two methods, the candle-power over small ranges of voltage has been assumed to vary on each lamp in the same proportion. But this assumes the same constant for each lamp which may or may not exist.

The standard lamp and the lamp to be tested may not be possessed of the same physical characteristics or the same ratios of graphitic carbon to base carbon in their filaments, any difference in either of which would have a direct influence on their light-giving qualities at different voltages. To eliminate all errors of this character, the third method wherein a storage battery is employed particularly commends itself to favor.

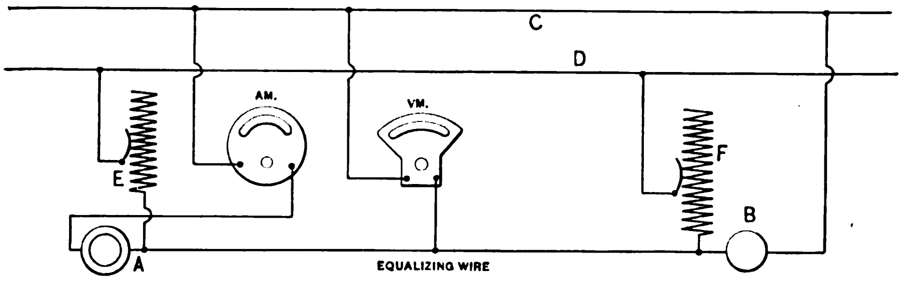


FIG 2.—DIAGRAM OF PHOTOMETER CONNECTIONS.

In Fig. 7, C and D represent two terminals of a storage battery of a sufficient number of cells to give double the potential needed for the lamps, at 1.8 volts per cell. From these cells is led off a three-wire service with two neutral conductors, I and J, connected respectively to one end of the variable resistances, E and F, in series with the lamps, A and B. Leads, L and K, complete the circuit through the lamps to the positive and negative ends of the battery. This battery may vary in ampere capacity, but for an ordinary central station a capacity of 10 ampere-hours at the discharge rate of 1¼ amperes per hour is sufficiently large.

The use of the battery provides for each lamp an isolated circuit of its own of absolutely constant potential. The standard lamp at B is adjusted to its proper voltage and remains without need of further attention. The object of splitting the neutral is to remove the slight fluctuation caused by the drop in this conductor when the lamp at A is removed. One side of the battery alone could be used for both lamps but the variable demand upon it would cause a slight fluctuation of the voltage at the standard lamp, which it is desirous of entirely eliminating for quick work. The voltmeter is connected through a double-pole switch across the terminals of either of the lamps, A and B, as in first method, and is left in circuit across A when a test is being made. Occasionally a reading across B is taken to see if the voltage has varied any, due to the discharging of the battery.

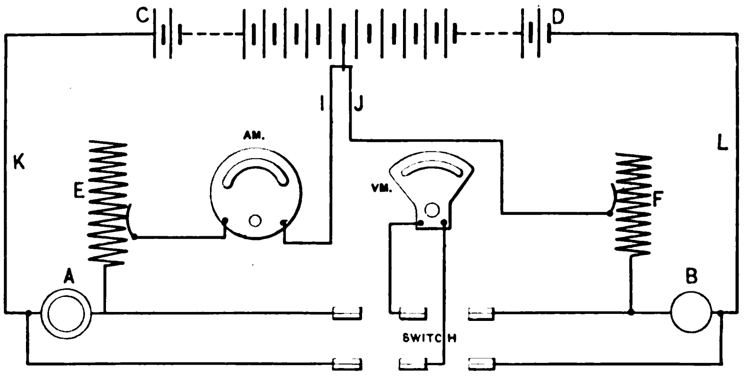


FIG. 3.—DIAGRAM OF PHOTOMETER CONNECTIONS, USING A BATTERY.

The lamp, A, is in a circuit which receives a constant potential, but the potential across the lamp varies with the current taken by the lamp, hence the variable resistance, E, is so placed as to be readily under the control of the operator.

The arrangement of the dark room is a matter which should be carefully planned to enable quick and accurate work to be done. The reading of the instruments should take as little time as possible and for this reason the large illuminated dial type of meter placed directly back of the photometer screen is the best for quick work. These meters may be mounted in any convenient manner, the controlling switches being within easy reach of the operator.

The scale divisions of the voltmeter should be large, which condition may be secured by using an instrument the range of which extends only about 15 volts above and below the voltage of the lamps to be tested. The ammeter need not read higher than 2 amperes in 0.01=ampere divisions. The scales of the instruments should be elevated slightly above the level of the top of the photometer screen; the values can then be read at a glance.

Unless a specific test is being made, an adjustable pointer on the ammeter is of great assistance in rejecting all lamps above a certain wattage, as it can be set at a given value and every lamp which runs the needle over this point, rejected at once.

The variable resistance on the lamp to be tested should be within easy reach of the left hand; in fact the operator's left need never leave it, as his right can be used to shift the screen.

In operating, the lamps to be tested in the rotating socket are removed by a boy who disposes of them according to the reader's call "good" or "bad." Usually the speed of the testing is entirely dependent upon the quickness with which the boy at the sockets can handle the lamps.

The reader's eyes should be shielded from the rays of the standard and tested lamps, and as it takes several minutes for the eyes to adjust themselves to reading the screen, the reader should not expose his eyes to extraneous light between readings. In testing a large number of lamps where extreme accuracy is not desired, advantage must be taken of every factor which reduces the time element of a test.

◆

THE SELECTION OF A STORAGE BATTERY FOR AN AUTOMOBILE.

BY GEO. T. HANCHET.

In the design of an electrically propelled vehicle there is no problem more important than the selection of a suitable storage battery, and before it can be done the speed and radius of the vehicle must be definitely determined. The method which it is the object of this article to set forth will be best illustrated by working out the problem for a given vehicle. The process can thus be shown with a minimum use of mathematics.

Let it be required to provide a storage battery to propel a two-passenger vehicle thirty miles at the rate of ten miles per hour on level road. It is at once evident that the selection of the battery must be based upon the three-hour discharge rate. It has been pretty thoroughly established by experience that we must have a capacity of 120 watt-hours per ton-mile if the construction and engineering design are of the best, but before this figure can be used, the weight of the vehicle must be estimated. The following assumptions may be made:

1. The weight of two passengers	300 pounds
2. The weight of the vehicle body dependent on the style to be adopted and the materials to be used but always computable	100 pounds
3. The weight of the controller, computable	30 pounds
4. The weight of the running gear similarly dependent on style adopted, but computable	200 pounds
5. The weight of the motors at present unknown	w
6. The weight of the batteries at present unknown	w
7. To these figures it will be well to add for wiring, instruments, lamps and fixtures	50 pounds
Making the total weight of the vehicle	680 + w + w pounds

The capacity of the battery in watt-hours, therefore, must be

$$\frac{\text{Tot'l wt.} \times \text{miles} \times \text{watt-hrs. per ton-mile}}{2000}$$

Inserting the figures previously assumed, this becomes

$$\frac{(680 + w + W) \times 30 \times 120}{2000}$$

which reduced to

$$1.8 \times (680 + w + W) = \text{watt-hrs.}$$

It may be profitably remembered that a good automobile battery can be built giving 6 watt-hours per pound of weight, or, if the type of cell to be used has already been determined, this figure can be accurately attained. Taking 6 as a fair value, and representing watt-hours by e,

$$W = \frac{e}{6} \text{ or } e = 6 \times W,$$

Hence,

$$\frac{1.8 \times (680 + w + W)}{6} = W =$$

$$204 + 0.3\,w + 0.3\,W.$$

Therefore $204 + 0.3\,w = 0.7\,W$, and

$$\frac{204 + 0.3\ \ w}{0.7} = W.$$

Now $6 \times W = e$, so that

$$6 \times \frac{204 + 0.3\,w}{0.7} = \frac{1224 + 1.8\,w}{0.7} =$$

$$1749 + 2.57\,w = e \ldots\ldots\ldots (2)$$

Automobile motors weigh about 150 pounds per kilowatt input, and if the type of motor is known, closer figures can be had. Continuing the calculation on the basis of 150 pounds per kilowatt, we may state that the input capacity of the motors is

$$\frac{e}{3 \times 1000}$$

kilowatts, because the total energy, e, in watt-hours is to be consumed in three hours; this is divided by 1000 to reduce E to kilowatt-hours. The weight of the motors, w, is therefore

$$\frac{150\,e}{3 \times 1000} = \frac{e}{20} = w,$$

as shown above (see formula 2)

$$1749 + 2\text{-}57\ \ w = e$$

and as $e = 20 \times w$, this formula becomes

$$1749 + \frac{2\text{-}57\,e}{20} =$$

$$1749 + .1285\,e = e;$$

and from this it follows that

$$e - 1749 = .1285\,e,$$

which makes $1749 = .8715\,e$, so that

$$e = \frac{1749}{.8715} = 2006 \text{ watt-hours,}$$

the battery capacity at a three-hour rate. From the foregoing we can at once calculate the weight of the battery.

$$W = \frac{3}{6} = \frac{2006}{6} = \text{practically 334 pounds}$$

The weight of the motor becomes

$$W = \frac{e}{20} = \frac{2006}{20} = 100.3 \text{ pounds.}$$

Its kilowatt capacity is

$$\frac{100.3}{150} = 668$$

And the weight of the vehicle, complete, with passengers, now lists as follows:

Passengers	300
Body	100
Running gear	200
Battery	334
Motor	100
Controller	30
Miscellaneous fittings	50
Total	1114

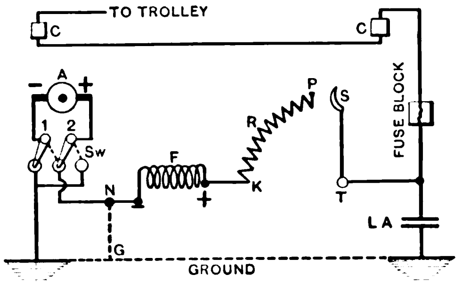
These results are based on the supposition that 120 watt-hours per ton-mile are correct at ten miles an hour. As a matter of fact, this figure varies with the speed of the vehicle, the character of the road, the condition of the gears, the kind of tires, the efficiency of the motors and many other things. The most that can be said is that it represents an average value, and the results obtained, therefore, must be tempered by experience and good judgment.

* * *

ELECTRIC CAR FUSES; WHY THEY BLOW.—I.

BY P. E. CHARLES.

The title of this paper might lead one to think that we are about to have a talk on fuses from the fuse point of view; but such is not the case: it is really a matter of no import in the present discussion whether the car has a fuse, or whether it is protected by a circuit breaker, just so it has some safety device that will act to prevent an excessive flow of current, due to whatsoever cause, from damaging the equipment. On a large road more cars are turned in for "blowing fuses" than for anything else. Of course the blowing of fuses is not the actual complaint within itself, it is merely the medium through which graver faults assert themselves. When a car persists in blowing fuses, it is safe to say that there is something the matter with the equipment. Once in a long while it may be found to be the case that the fuse is too small for the motor it is protecting. This can come about in two ways: it may be due to the storekeeper's fault in giving out the wrong size of fuse-wire, either by mistake, or because there is none of the right size in stock; or it may be due to the original motors having been replaced by larger motors. As the fuse boxes are on the car bodies, they may not be changed with the motors, and the chances are that the cars will go out with the same fuse in them. The motorman, if he follows his orders, will put in the same kind of a fuse that he takes out, so the car will keep on blowing fuses.



American Electrician

FIG. 1.

As a rule, though, it is more apt to happen that the fuse is too large than that it is too small. To properly protect the motors, the fuse should be of such a size that it will blow in about two weeks, even if nothing in the way of a breakdown occurs to blow it; if the fuse is of a safe size it will become oxidized under normal usage in due course of time, and blow. Assuming the size of the fuse to be right, a loose connecting post in the fuse box will cause it to blow, because the current always generates most heat where it meets with the most resistance, and as the resistance of a poor contact is high, the heat caused there melts the end of the fuse. Another cause of blowing fuses is a ground on the lightning arrester or on some part of a motor or controller. A ground on the arrester is generally due to the spark plates being short-circuited, either by a piece of foreign matter, or by actual contact due to jolting of the car, and want of adjustment in the arrester itself; such a ground will always blow the fuse as soon as the trolley is put on the wire, but it can be removed, of course, by cutting the lightning arrester ground wire. A ground on either of the motors or controllers is almost always announced by more or less smoke and fireworks, and can, as a rule, be removed by means of the motor cut-out.

How the car will act when a ground takes place on one of the motors depends a great deal upon where the ground is located. In certain places, the occurrence of a ground on a motor or on some wire running from the motor to the controller, is attended by a sudden drop in the speed of the car, generally known as bucking, and before taking up the question of the faults to which such action may be due, we will try to explain the action itself. Fig. 1 is a wiring diagram for a car equipped with an old-style rheostat and reverse switch. Here, C and C are the two hood switches; LA, the lightning arrester; T, the rheostat trolley connecting post; S, the contact shoe; R, the half-moon part of the rheostat; F, the motor field; 1, 2, the reversing switch; A, the motor armature; and G, an accidental ground. When shoe, S, touches the half-moon of the rheostat, the path of the current from the trolley wire to the ground is C, C, fuse-block, T, S, P, R, K, F, N, 2, A, 1 and to the ground. On this position all of the resistance is in circuit; when the shoe, S, is moved around till it touches K, all of the resistance is cut out, of course. If a ground takes place on the negative end of the field, anywhere from F — and A +, say at the point, N, the armature is evidently short-circuited, practically all of the current passing to the ground at G, because of the counter e.m.f. of the armature. But in taking this short path to the ground the current must pass through the field of the motor, and in so doing it excites it—you might say, separately excites it.

When the resistance, R, is all cut out, and since the resistance of the coarse wire field winding is very low, the flow of current through the fault at N is very great, and it puts an abnormally strong field on the motor. Now it must be borne in mind that the brushes of the armature are dead short-circuited by the accidental ground, so that as soon as such a ground occurs with the car under headway, the armature is running on short-circuit, in a strong field, and, therefore, generating a powerful e.m.f. of its own. As soon as it does this, the motor becomes a dynamo, driven by the car axle, and the work of driving the separately excited armature as a generator on short-circuit pulls down the speed. As this load on the car is suddenly imposed, the car speed is as suddenly checked.

Of course the whole thing takes place in a moment, and the main motor fuse blows at about the same time that the bucking occurs, because it cannot stand the heavy current that flows through the motor field. Such a ground, as a rule, occurs at a brush holder, and this, in turn, may be due to any one of several causes. Among these may be mentioned abuse, loose connections, low voltage, roasted fields and wrongly-connected fields. A small book could be written about almost any of these.

The abuse to which most of the grounded brush holders are due is to be found in the handling of the controller, in going from series to parallel. It must be borne in mind that a motor field is self-inductive, and a current will take almost any other path open to it rather than force its way through self-induction in a short time. When the controller handle is thrown from series to parallel it means that certain combinations of circuits have been broken, and that new ones must be made; and the current must get through the new ones. If the controller handle is worked right on around to the last series notch, without giving the car speed any chance at all to respond to the successive changes that have been made on the several series notches, and is then "flopped over" to the multiple position, the resulting heavy current causes the brushes to spark, and that same current, rather than instantly pass through the self-induction of the new paths presented to it, will jump across to the motor frame, using the carbon dust and copper vapor incidental to the sparking, as a bridge to cross on.

Where the line voltage is very low there is much more trouble with fuse blowing and general motor and controller breakdowns than on a line where the voltage is kept well up. Especially is this the case on a line where the voltage was at one time well kept up, but which has been lowered by extending the road and increasing the load without increasing the line copper so as to keep up the voltage. This is a fact well known to railway men, but many of them have only a partially correct idea as to why it is so. Many have drawn conclusions thus: Work equals e.m.f. × current; therefore if the voltage is low, the current must be high. This is true where there is a given amount of work; but it must be borne in mind that on a series motor, as railway motors are, the current remains practically the same, whatever may be the voltage applied to it. The current really increases a little as the voltage increases. Where there is an armature in the circuit no more current can be forced through that circuit than the counter e.m.f. of the armature lets through, and unless the motor field be weakened or the mechanical load on the armature be increased, the speed increases whenever the line voltage does, and the counter e.m.f. increases with it. The real reason why there is so much fuse blowing on a low-voltage road is that in most cases the time tables for the road were made out when the voltage was well up, and are kept in use after the voltage has lowered, with the result that the motorman can recognize only two notches on his controller if he wants to get a quick start, and must run the car on the loop a great deal of the time when it ought to be coasting along without any current at all. The final effect is that the motors run warmer and the fuses blow because they can't stand the large average current.

Wrongly-connected fields and roasted fields are closely akin, in that the one can cause the other. Take a brand new equipment and get one field in one of the motors connected wrong, and the car will be run in within a short time for blowing fuses. The reason is that if one of the fields is in wrong, part of the magnetic field is neutralized on that motor; the result is that the counter e.m.f. is lower than it should be at any given speed, and lets in a larger current than the motor can stand. In course of time, the excessive heat carbonizes the insulation on the wire, and the current, instead of going around every turn of wire on the field coil, passes across directly from one layer to another, thereby further weakening the field and increasing the current to a value beyond the capacity of the fuse. Wrong connection in the fields is one of the most prolific causes of roasted fields and blowing of fuses that exists.

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THE ELECTROLYTIC PRODUCTION OF SODA AND CHLORINE.—IV.

BY JAMES F. HOBART.

The meaning of the term "electrolysis" is chemical decomposition effected by means of the electric current. When an electric current is sent through an electrolyte, the decomposition which ensues is called electrolytic decomposition, or, in short, electrolysis. The electrolyte is decomposed or broken up into atoms, or groups of atoms, or radicals, called ions. The ions are of two distinct kinds, viz.: electro-positive ions, or kathions, and the electro-negative ions, or anions. Since the anode of the electric source is connected with the electro-positive terminal, it is clear that the anions, or the electro-negative ions, must appear at the anode, and the kathions, or electro-positive ions, must appear at the kathode.

Hydrogen, and the metals generally, as given in the table presented last month, are kathions. Oxygen, chlorine, iodine, etc., are anions. The vessel containing the electrolyte, anode and kathode, and in which the decomposition takes place, is sometimes called an electrolytic cell. Such a cell is sometimes also called a voltameter when it is arranged for measuring the current passing through it. This is done by measuring (by weight) the amount of decomposition effected.

With the above explanation we can comprehend Faraday's laws of electrolysis, the principal ones of which are given herewith:

(1) The amount of chemical action in any given time is the same in all parts of the circuit.

(2) The number of ions liberated in a given time is proportional to the strength of the current passing. Twice as great a current will liberate twice as many ions. The current may be regarded as being carried through the electrolyte by the ions; since an ion is capable of carrying a fixed charge of positive or negative electricity, and increase in the current strength necessitates a change in the number of ions liberated.

(3) When the same current passes successively through several cells containing different electrolytes the weight of the ions liberated at the different electrodes will be equal to the strength of the current multiplied by the electro-chemical equivalent of the ion (see table in last paper).

Another law has been formulated by Kohlrausch concerning the velocity of electrolytic conduction. He deduces that each atom has a rate of motion for a given liquid which is independent of the element with which it may have been combined. In the following table the rate of motion of the various kinds of atoms through nearly pure water is given for a difference of potential of 1 volt per lineal centimetre:

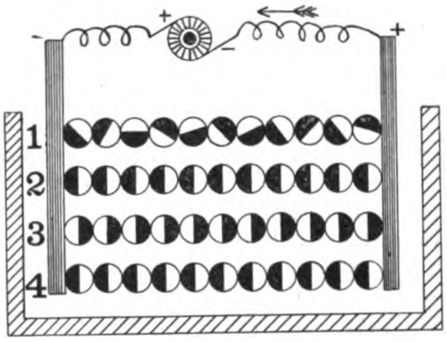


FIG. 1.—GROTTHUSS HYPOTHESIS.

H. (Hydrogen) 1.08 centimetres per hour.
K. (Potassium) 0.205 centimetre per hour.
Na. (Sodium) 0.126 centimetre per hour.
C. (Carbon) 0.213 centimetre per hour.
I. (Iodine) 0.216 centimetre per hour.

Hydrogen travels the fastest of any element, and when produced by electrolytic process possesses qualities different from the gas produced by chemical means. The latter may be called "molecular" hydrogen, there being two atoms in each molecule. In the electric decomposition of water electrolytic oxygen is evolved at the same time as the electrolytic hydrogen. Electrolytic oxygen has been successfully employed in bleaching. Hydrogen peroxide (H_2O_2) is also formed, and this, too, acts as a bleaching agent.

The action set up during electrolysis is explained in two ways: one advances the theory that electricity is a single fluid, the other presents a double fluid scheme, whereby the atoms (ions) go to their respective electrodes by means of separate positive and negative currents of electricity. Lodge favors the double fluid hypothesis, but Grothuss advances and ably supports the single fluid hypothesis. It seems, too, as if Faraday also favored the latter. Fig. 1 represents Grothuss' conception of what is going on during electrolysis. His hypothesis is that, as shown at the upper level of molecules (1) before the electric circuit is closed through the cell, the molecules are arranged in an irregular condition at the upper row or layer; but when current is forced through the cell the molecules all arrange themselves as shown at (2). There the sodium side of each molecule, being electro-positive, turns toward the kathode; the chlorine, being electro-negative, is attracted in the other direction. As long as this state of things continues the cell is said to be polarized, and there is no change in the position of the atoms, and this will continue as long as the current of the electricity is just about equal to the electrical tension between the atoms in each molecule; but let the electrical power be increased sufficiently to overcome the e.m.f. of the electrical union which exists between the chlorine and sodium, and they are torn apart, each going to its respective electrode.

According to Grothuss, when the circuit is closed and polarization is effected there occurs a decomposition of the polarized chain, whereby the chlorine of the outermost molecule goes to the anode, and the atom of sodium thus liberated at once unites with the chlorine of the molecule nearest to it, the sodium of that molecule in turn going to the chlorine of the next, and so on through the entire chain, as shown at (3). The next action is at (4), when there is shown a semi-rotation of the molecules caused by the readjustment described in the preceding paragraph. The molecules are now in position again to go through the same cycle over again, and the process is continued as long as the current is of sufficient strength to overcome the resistance of the electrolyte and apparatus.

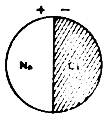


FIG. 2.

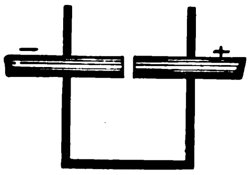


FIG 7.

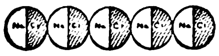


FIG. 3.

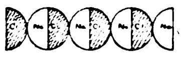


FIG. 4.

A molecule is shown by Fig. 2 as "conventionalized" for the purpose, and Fig. 3 shows a chain of these molecules; Fig. 4 gives a view of them after one atom of Na and one of Cl have been translated to the anode and kathode respectively. The affinity of the electrolytically separated chlorine is so great for the sodium that it at once lays hold of and unites with the sodium of the molecule next to it, as shown by Fig. 5. This readjustment is continued through the entire chain, and through the millions and billions of chains which go to make up the body of the electrolyte. The result is that each chain has one molecule less when the reconstruction is finished, as shown by Fig. 6; but another molecule at once falls into line from the surrounding body of electrolyte. The molecules swing half way around under the polarizing effect of the electric current, and take the position shown in Fig. 7, which is exactly the same as in Fig. 3. This forms a complete cycle of the operation of electrolysis, and one which is constantly repeated until atom by atom the molecules of NaCl are decomposed into sodium and chlorine.

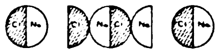


FIG. 5.

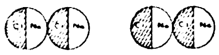


FIG. 6.

From a study of this theory of electrolysis it must seem to the reader that there should be a considerable saving in electrical power by making the molecular chains as short as possible. To a certain extent this is so, but the electrodes should not be brought so close together that there is no opportunity for the escape of the liberated ions. If the anode becomes covered with chlorine, thus greatly increasing the ohmic resistance of the electrolytic cell, there should be space enough between the anode and the kathode to permit free circulation of the electrolyte. Beyond this the electrodes should be close together.

As an approach to the commercial electrolysis of NaCl, consider the situation when two carbon rods are placed in a vessel of salt solution and the current is up with a dynamo, as shown in Fig. 8. Here the chlorine and sodium thus liberated react upon each other and form sodium hypochlorite (NaOHCl). The sodium (Na) liberated by the electrical current at once unites with hydrogen and oxygen from the water in which they are in solution, and form caustic soda, NaOH. When the chlorine recombines with this substance the hypochlorite of sodium is formed directly in the electrolytic cell. It is only necessary to heat this chemical in order to decompose it and to cause it to give off chlorine gas readily. Chlorine gas has such an affinity for hydrogen that it will take it away from the water in which the sodium chloride is dissolved, thereby forming hydrochloric acid (HCl). In order to obtain the chlorine alone, another method will be required, and the electrodes must be separated by a diaphragm, or some form of porous material, which will permit electricity to pass, but which will effectually stop any of the ions from becoming mixed up with each other after they have been separated. To this end, the electrolytic cell and diaphragm will be discussed in the next article.

INTERIOR TELEPHONE SYSTEMS.—II.

BY W. S. HENRY.

The next step in the refinement of interior telephone systems is the addition of an induction coil for each station equipment. Fig. 7 represents a series party system (corresponding with that which was shown at Station 1 in Fig. 4) in which a battery, B, and vibrating bell, V, are used for signaling, and an induction coil, I, is added to the speaking apparatus. The primary of the induction coil is in series with the microphone transmitter, T, and its battery, M B, and the secondary is in series with the telephone receiver and the line. As in the previous cases, only one of the bells must be allowed to vibrate, the vibrators on the others being short-circuited. The signaling lever, l, is normally held against the upper contact by a spring, leaving the battery, B, out of circuit; the telephone hook, H, is held down by the receiver, leaving the local circuit through the transmitter and primary of the induction coil open and the telephone receiver cut out from the line. It is obvious that depressing the lever, l, will cause all of the bells to ring, and that allowing the receiver hook, H, to rise will close the transmitter and receiver circuits.

The connections at Stations 1 and 2 are identical; when the receiver hook, H, is down the talking instruments are entirely cut out, and when it is up the signaling key, battery and bell are thrown entirely out of circuit and the main circuit passes through only the telephone receiver and the secondary of the induction coil. At Station 3 the connections are different; when the receiver hook is down the telephone receiver and secondary of the induction coil are merely short-circuited, while the transmitter, its battery, and the primary of the induction coil are open-circuited. When the hook is up, the talking instruments are connected

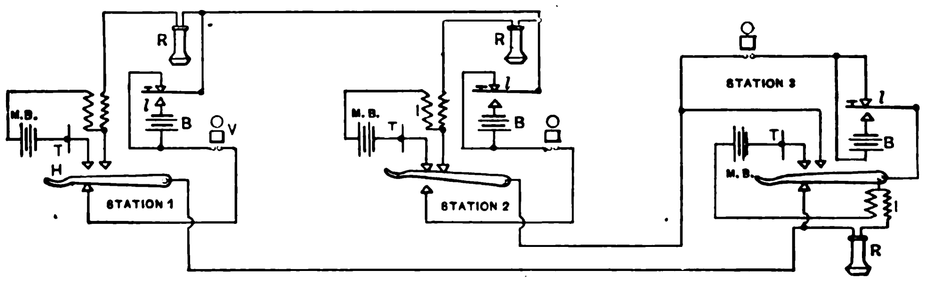


FIG. 7.—SERIES PARTY SYSTEM, WITH INDUCTION COILS AND SIGNALING BATTERIES.

up for service and the signaling part of the apparatus is short-circuited. Fig. 8 corresponds with Fig. 7, except that magneto generators, G, and magneto bells, C, have been substituted in the place of the signaling battery and vibrating bells shown in Fig. 7. The station connections correspond also, the receiver hook, H, at Stations 1 and 2 being arranged to throw in and out of circuit the talking apparatus and the signaling apparatus, while the hook at Station 3 merely short-circuits the signaling apparatus or the receiver circuit, according to its position. This arrangement is the preferable one of the two for the reason that faulty switch contacts at the receiver hook will not open the circuit, so that there will always be a continuous line through which one may signal.

As described in the previous article, the magneto generator may be provided with an automatic short-circuiting arrangement on its spindle or with the outside push button, k, shown in the diagram. In both of the arrangements just described, it is evident that the talking current must flow through the signaling bells of all the stations except the two in communication with each other, which is a disadvantage, as previously noted, on account of high self-induction of the bell magnets. The result is that a series system of this kind is not satisfactory for a considerable number of stations, four or five being the usual practical limit. The transmitter batteries in these and any other systems having distinct transmitter batteries, may consist of two good Leclanche cells with large zincs, which give about the best satisfaction.

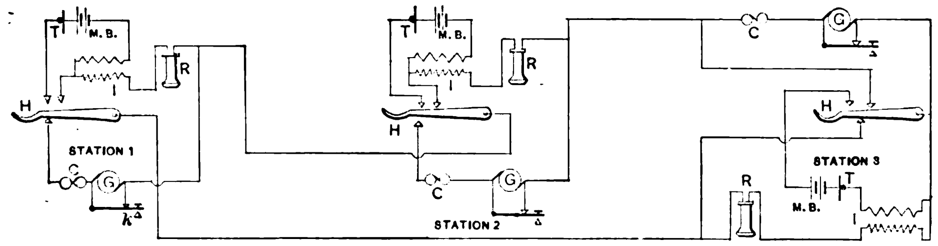


FIG. 8.—SERIES PARTY SYSTEM USING INDUCTION COILS AND SIGNALING MAGNETOS.

A simple system installed by Mr. D. H. Fitch in a factory where there was considerable noise, dirt and vibration, is represented diagrammatically by Fig. 9. Here there are three line wires, a, b, and c, the line, c, forming a common return for both the signaling and the talking circuits, a and b, on which the apparatus is arranged in series. In this system the talking line is never open-circuited, the telephone hook, H, serving to merely short-circuit the receiver and the secondary of the induction coil when down and to remove the short-circuit and close the local circuit of the transmitter and induction coil primary when up. It is obvious that the middle line wire, c, gives a free path to the talking current instead of its being forced through the signaling bells. Such an arrangement facilitates the separation of the signaling and talking apparatus, so that the call bells can be located where they can be easily heard, while the transmitter and receiver may be put in a sound-proof closet. The disagreeable noises due to induction from lighting or power circuits may be overcome by using a twisted three-conductor cable between stations. Such an installation is greatly superior to the series system shown by Figs. 7 and 8.

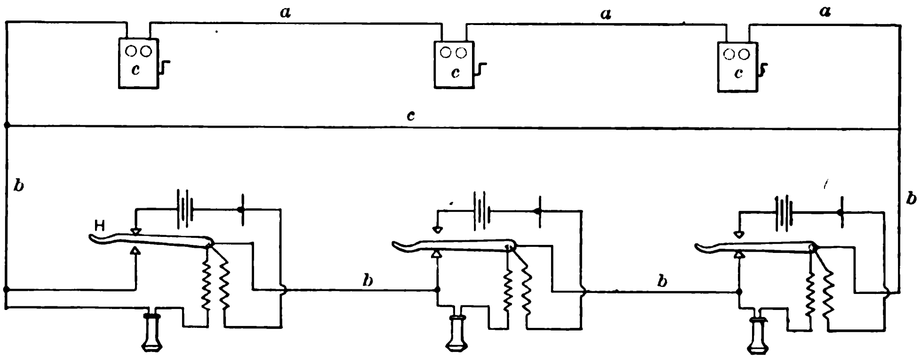


FIG. 9.—THREE-WIRE SERIES PARTY SYSTEM.

Fig. 10 shows a series system in which one battery is used both for signaling and for talking. In this system the connections are alike at all the stations; when the receiver hook, H, is down and the signaling key, l, is up, there are included in the line circuit only the vibrating bells. Depressing the signaling key, l, puts the battery in the line and causes all the bells to ring. It is preferable to have the batteries so connected up that if two or more signaling keys should be depressed at once the batteries will agree in polarity. When the receiver hook is up the battery is connected in series with the transmitter and the primary of the induction coil, while the signaling key and bells are thrown out of circuit and the telephone receiver and secondary winding of the induction coil are included in the line, as shown at Station 3.

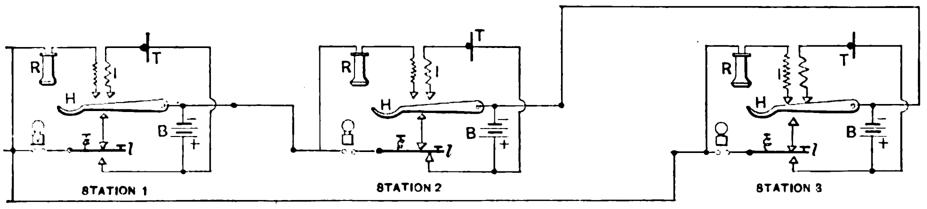


FIG. 10.—SERIES PARTY SYSTEM USING ONLY BATTERY AT EACH STATION FOR BOTH TALKING AND SIGNALING.

In this, as in previous series systems, with the exception of Fig. 9, the talking current must flow through the signaling bells at idle stations. The advantage of the system is obviously that it eliminates half of the batteries, only the one battery being used at each station for both signaling and talking. As in all series systems where vibrating bells are used, the vibrators should be short-circuited on all bells except one.

The best method for connecting a large number of telephones on a single system where only two line wires may be used is to bridge them, as shown in Fig 11. The dots, A and A′, represent the binding posts of each complete outfit. The bells are permanently bridged between the two line wires at Stations 1, 2 and 4, irrespective of the position of the receiver hooks. The magneto generator is also bridged across the two line wires in an independent circuit, which is normally kept open either by a push-button, k, or by an automatic device on the magneto spindle.

At Station 3 the magneto generator is bridged permanently across the line, as in Stations 1, 2 and 3, but the bell is connected across only when the receiver hook is down, being thrown out when the hook is up. At Station 5 the bell and generator are bridged across the line wires when the receiver hook is down and are cut out entirely when it is up. At all of the stations a third bridging circuit includes the receiver and the secondary winding of the induction coil in series, this circuit being open when the receiver hook is down and closed when it is up. The hook also closes the local transmitter circuit in the usual way when it is up and opens it when it is down. The connections shown at Stations 3 and 5 possess the advantage of cutting out their signaling bells entirely when the receiver hooks are up instead of leaving the bells shunted across the line continuously, as is the case at Stations 1, 2 and 3. On the other hand, there is the slight additional complication of a contact below the hook.

It is evident that with this arrangement the current from any one generator will split up and pass through all of the bells in parallel, just as the dynamo current does through incandescent lamps in an ordinary lighting system; hence a different number of rings must be used to call up the different stations, just as in the series systems. Moreover, the armature of the magneto must be wound for this class of service as distinguished from series service; in the latter the generator needs a high e.m.f. and small current, whereas in the bridging system the e.m.f. is comparatively small and the current comparatively large. It will also be evident upon studying the diagram that with this arrangement the signaling bells at all of the stations except Nos. 3 and 5 will be connected in shunt to the telephone receivers. As explained in the previous article, this is not a serious disadvantage because the bells are wound to high resistance and high inductance, so that they offer a very high impedance to the rapidly fluctuating talking current and the leakage is therefore negligible.

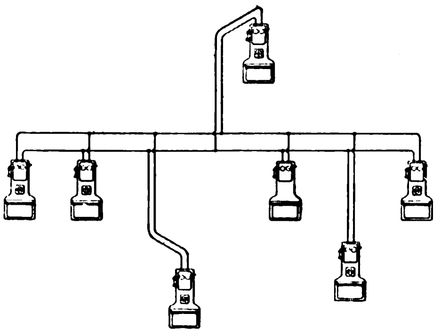


FIG. 12.—BRIDGED LINE.

As in the case of incandescent lamps on constant-potential circuits, the various telephones of a bridging system do not need to be located near the main line wires, but can be tapped off as shown in Fig. 12. This method is used in telephone exchange systems for connecting up a number of subscribers in a single circuit. In an interior telephone system it is not advisable to use it for more than seven or eight stations because only two stations can talk at once, and if the system is likely to be kept fairly busy it is liable to inconvenient interruptions and delays.

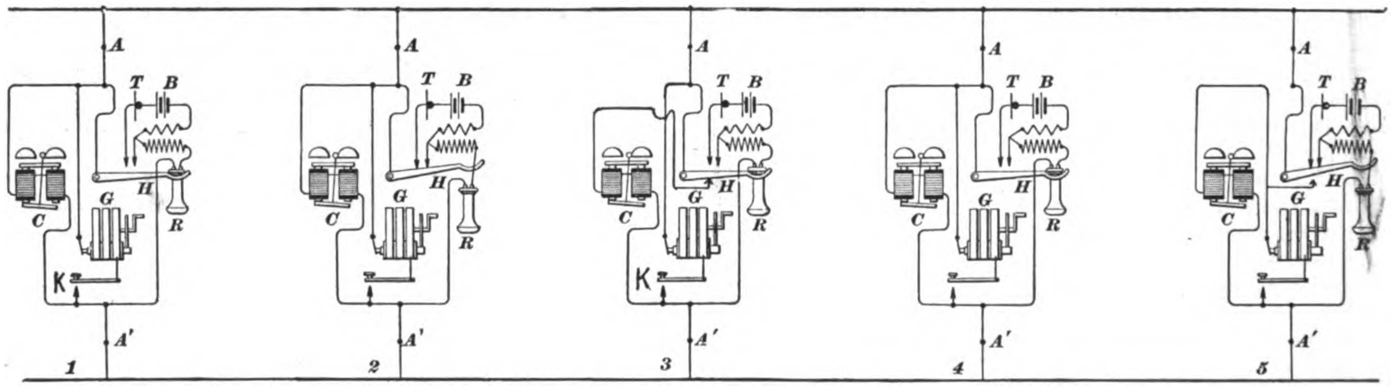


FIG. 11.—BRIDGING PARTY-LINE SYSTEM; THREE ARRANGEMENTS OF STATION INSTRUMENTS.

Fig. 13 shows the connections of what is known as the Carty bridging bell telephone set, in which is used a Warner receiver-hook switch. In order to make the diagram clearer, the location of the switch contacts has been slightly changed, the contact springs, m and n, being shown one behind the other instead of side by side as they are in the actual apparatus. The diagram also shows the open-circuiting device on the magneto spindle, to which reference has been made previously. Normally, the magneto circuit is open as shown in the diagram, the spring, d, being held away from the contact, c, by the spindle. When the spindle is turned a pin at I slides on the V-shaped face of the hub of the driving wheel, which pulls the spindle away from the spring, d, and allows the latter to come in contact with c, closing the generator circuit. This device is also made to act in the reverse direction when the magneto is connected in series with the call bell, as described in this and the previous article; in which case the armature is normally short-circuited and turning the handle removes the short-circuit. The diagram shows the receiver hook in its "down position. When the receiver is removed and the hook rises, the projection, a, comes in contact with the springs, m and n, closing the local transmitter circuit and also closing the line circuit through the receiver. When the hook is down, the insulating piece, b, prevents the springs, m and n, from coming in contact with the projection, a.

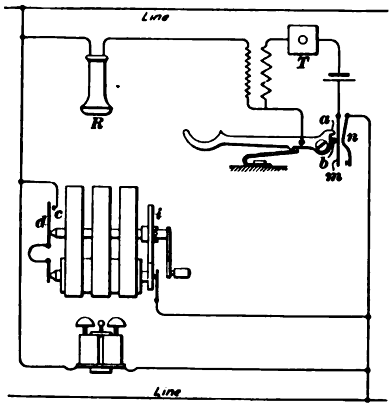


FIG. 13.—CARTY BRIDGING SET.

This hook can be used to perform the functions of the hooks represented diagrammatically at Stations 1, 2 and 4, in Fig. 11, by transposing the connections to the switch lever and the spring, n, and leaving the connection from the spring m, to the transmitter circuit as it is shown in the engraving (Fig. 13).

Lessons in Practical Electricity

TRANSFORMERS.

It may have been noticed by the reader that the primary ohmic drop, V, is plotted in the same direction with the primary current vector, C, while the secondary drop, v, is shown in opposition to the secondary current, c. The plotting of the primary ohmic drop is correct; that of the secondary ohmic drop is reversed in the diagram in order to indicate vectorially that it is subtracted from the induced e.m.f., e_1. leaving the delivered e.m.f., e. In order to correctly indicate the direction of the secondary ohmic volts the arrow-head, v, should be on the right-hand side of the origin point, 0; but this would make it geometrically additive to the induced e.m.f., e_1 which is untrue. Of the two inaccuracies, the one of direction is least objectionable because it does not affect ultimate results, whereas if the direction of the secondary ohmic e.m.f. be correctly plotted it cannot be represented graphically as subtractive from the induced e.m.f., and all of the ultimate results will be erroneous.

There remains one more correction to be made before the diagram will show the phase relations which exist in practice; this is the correction for magnetic leakage. It is impossible to arrange the coils so as entirely to prevent magnetic leakage of lines between them, and the effect of this magnetic leakage is exactly the same as though the leakage lines were the only ones in existence. The reactive e.m.f of any coil, taken alone, lags a quarter period behind the current that produces it, as explained in the April article. No matter what influence may affect the phase relation between the impressed e.m.f. and current, the reactive e.m.f. lags 90 deg. behind the current in phase.

Therefore a component of the primary impressed e.m.f. is required to oppose the reactive e.m.f. in the primary winding due to magnetic leakage of lines of force which do not pass through the secondary winding; as this component is in the opposite direction to the reactive e.m.f., which lags behind the current, it will lie ahead of the current in phase, as shown in Fig. 14, where the vector, F_x, represents the component of impressed e.m.f. consumed by primary reactance. The existence of this component changes the phase relation of the impressed e.m.f. with respect to all of the other vectors. The resultant of the vector, E_x, and that representing the ohmic drop, V, is as shown by the vector, E_z, and may be called the impedance component; and the impressed e.m.f., E, is the resultant of this impedance component and the induced e.m.f., E_0, so that the impressed e.m.f. is really ahead of the induced e.m.f. as shown in Fig. 14, instead of behind it, as shown in the preceding diagrams.

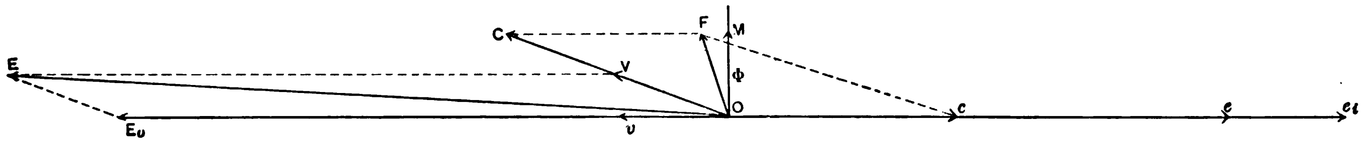


FIG. 13.—PHASE RELATIONS WITH THE SECONDARY CIRCUIT CLOSED, TAKING INTO ACCOUNT HYSTERESIS AND EDDY CURRENTS.

It will be noticed that throughout all the changes, the phase relation between the magnetic flux, Φ, the resultant, F, of primary and secondary ampere-turns, and the induced e.m.f., E_0, remains absolutely fixed. No matter how the primary current may vary in phase or value (varying with it the phase and value of the ohmic, reactive and impedance, e.m.f. components and also affecting the phase of the impressed e.m.f., E), the relation between the vectors, E_0, F and Φ, never changes. The reason for this will become apparent when it is remembered that the magnetic flux remains practically constant regardless of variations in load on the transformer, so that the hysteresis loss remains constant; consequently the phase of the ampere-turns, represented by F, necessary to produce the magnetic flux, remains fixed. And as the induced e.m.f., E^o, is that produced by the magnetic flux, the phase relation between the flux and this e.m.f. is constant. The variations in phase relation of the other factors will be discussed further along.

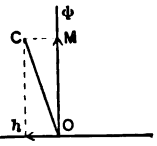


FIG. 11.—SHOWING THE DIFFERENCE OF PHASE BETWEEN THE MAGNETIC FLUX AND THE EXCITING CURRENT DUE TO HYSTERESIS AND EDDY CURRENTS.

In the secondary circuit there is no e.m.f. impressed from the outside so that the reactive e.m.f. due to magnetic leakage is not opposed by anything, but merely serves to reduce the delivered e.m.f. The secondary reactive e. m. f., therefore, is plotted as lagging behind the current, as shown by v_x, Fig. 15. As in the case of the primary, the combination of the reactive and ohmic e.m.fs. gives the impedance e.m.f., v_z, and the difference between this and the induced e.m.f., found by the parallelogram method, is the delivered e.m.f., e, which lags in phase behind the induced e. m. f., e_1. The diagram Fig. 15, shows the phase relations in the secondary when the load is absolutely non-inductive, so that the secondary current is in phase with the circuit e.m.f., e.

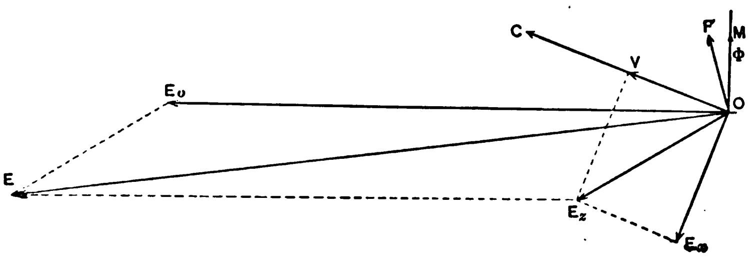


FIG. 14.—PHASE RELATIONS IN THE PRIMARY WINDING, CORRECTED FOR MAGNETIC LEAKAGE.

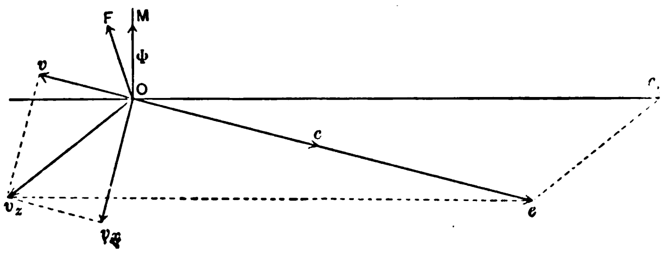


FIG. 15.—PHASE RELATIONS IN THE SECONDARY WINDING, CORRECTED FOR MAGNETIC LEAKAGE.

Having analyzed the actions in the primary and secondary circuits separately, it only remains to combine the diagrams last shown in order to show graphically the condition of affairs in the entire transformer when the secondary load is non-inductive. Such a diagram is shown by Fig. 16, in which all of the reference letters have the same meaning that is attached to them throughout.

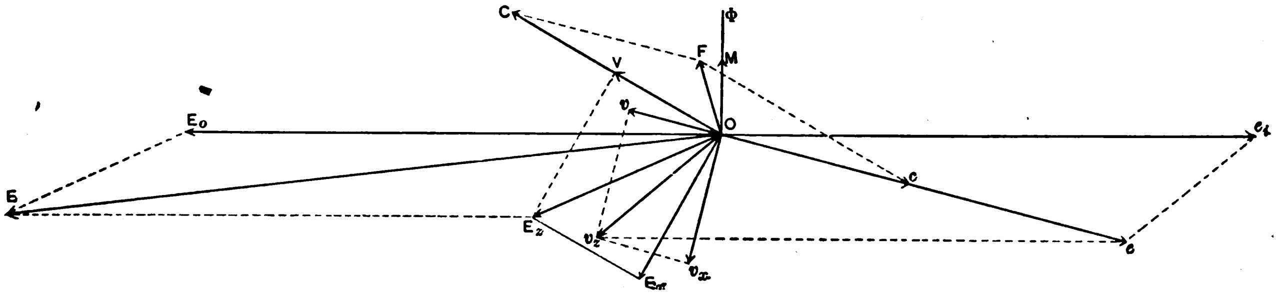


FIG. 16.—COMPLETE DIAGRAM OF PHASE RELATIONS WITH A NON-INDUCTIVE LOAD ON THE SECONDARY.

Summing up the various effects, there is first the magnetic flux, represented by Φ; the magnetizing component of the combined primary and secondary ampere-turns, represented by M; the core-loss component, not shown in this diagram, but represented by h in Fig. 11; the resultant of this core-loss current and the magnetizing current, M, which is represented by F in Fig. 16; the primary current, C, and secondary current, c, the resultant of which is F; the primary ohmic e.m.f. component, V, which forces the current through the winding; the primary e.m.f. component, E_x, which opposes reactance; the resultant of these two, or the primary impedance component, E_z; the component, E_0, opposing the induced e.m.f., and the resultant of this component and impedance component, which is the impressed e.m.f., E; the secondary ohmic drop, v; the secondary reactance drop v_x; the resultant of these two or the secondary impedance drop, v_z; the secondary induced e.m.f., e_1 and the difference between this induced e.m.f. and the impedance drop, which is the delivered e.m.f., e, and given by the parallelogram method.

In all of the diagrams the vectors are supposed to revolve counter clockwise about the center, in considering the phase relation as to lead and lag, and, as previously stated, the lengths of all of the short vectors and most of the angles are exaggerated in order to make the diagrams intelligible.

Letters on Practical Subjects

Advice Offered.

To the Editors of American Electrician:

Sirs: In answer to Mr. Smith's inquiry in the May number of your paper, I would put in another alternator and supply alternating current to the town, using there a rotary converter for the motor supply, and supplying alternating current for the lights alone.

H. P. Ballou.

Chicago, May 9, 1900.

To the Editors of American Electrician:

Sirs:—Referring to the request for suggestions by Mr. Gus Smith, in the May number, I would favor the use of a rotary converter and direct-current motors, because of the higher efficiency of direct-current motors; the fact that consumers are usually better satisfied with them; the absence of lagging currents, and the generally better satisfaction of consumers of both light and power. The Cudahy Packing Company, at the South Omaha plant, has a two-phase plant using induction motors, and I have been informed that the operation of it was not entirely satisfactory; this seems to be confirmed by the fact that in both of their plants, recently installed at Sioux City and at Kansas City, direct-current power apparatus is used exclusively. A similar case is the large plant of the Armour Packing Company, at Chicago. The local electric lighting company here supplies induction motors and lights from the same machines and the regulation of voltage and, consequently, the illuminations are very poor. This station operates alternators in multiple and is much troubled by the machines hunting and a consequent "pumping" of the lights. This and other matters has caused the Welsbach gas lamp to make large inroads on the company's business. For the above reasons, I favor direct-current motors if you would keep your light consumers satisfied with the service, and this satisfaction means dollars and cents and dividends.

F. M. Van Dervoort.

Omaha, Neb., May 8, 1900.

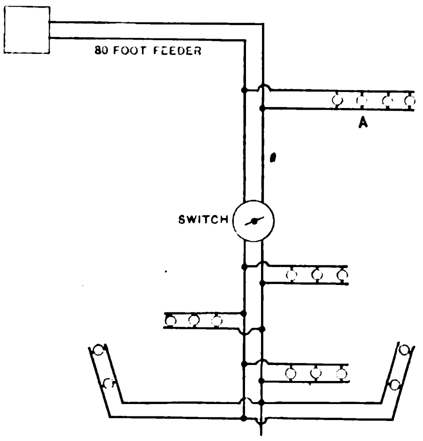
◆

Unusual Circuit and Static Troubles.

To the Editors of American Electrician:

Sirs:—Our series arc line had been going open and shut for some time, being worse in windy weather. One day it stayed open long enough for a test. We finally located the break between two lamps. On going to the top of one of the suspension poles we found the line broken but held together by the insulation on the wire. When the wind blew the ends of the wire separated, but when the wire remained still the circuit was closed.

In a church here we have some fixtures on a large wood ceiling, polished and varnished. In one of these fixtures a new lamp would give a spark along the filament when the current was turned on, and then would be burned out. I remedied this by putting a strip of tin on the ceiling and connecting the tin to the ground.



In a secret society hall we have 17 lights, wired as in the diagram given. On closing the switch the lights on the first branch, A, would be extinguished for four or five seconds, while the others would light immediately. By rapidly turning and closing the switch the lights inside and outside of the switch would burn alternately. This was remedied by increasing the size of wire used in the 80-foot feeder. An alternating, single-phase current was used.

J. W. Swann.

Robinson, Ill., March 25, 1900.

◆

Railway Joint Testing.

To the Editors of American Electrician:

Sirs:—Referring to the description of Lord Kelvin's rail tester in your May issue, I would call your attention to a similar arrangement that has been in use in this state and Connecticut for several years. Fig. 1, enclosed herewith, shows the tester in use. The box, carried by one operator, has in it a vibrator like that of an induction coil, a three-point switch, and two resistance coils of exactly equal resistance. The circuits within the box are connected by a flexible cord to a telephone receiver which is shown strapped to the head of one of the operators. Fig. 2 shows the complete circuits of the outfit; a, b, c are the pikes, which are lettered in the same way in Fig. 1; T is a telephone receiver; V, the vibrator; S, the three-point switch, and R and R are the resistance coils.

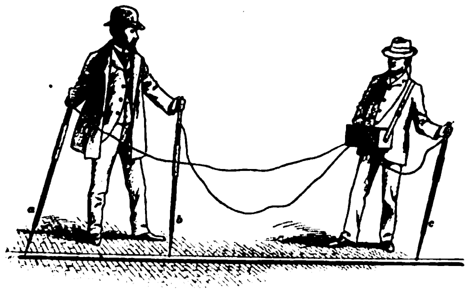


FIG. 1.—RAIL BOND TESTER.

In making a test the pikes, a and b, are held on the rails just outside of the ends of the rail-bonds and pike, c, is applied to one of the rails about the same distance from b that b is from a; the switch, S, is thrown from side to side and the pike, c, is moved a little farther away each time until the clicking in the telephone is about the same strength no matter which of the outer buttons the switch finger rests on. Then the switch finger is moved to the center button and the pike, c, is moved back and forth until a point is reached where the telephone does not give any sound at all; then the resistance of the rail from b to c is exactly the same as the resistance across the joint from a to b.

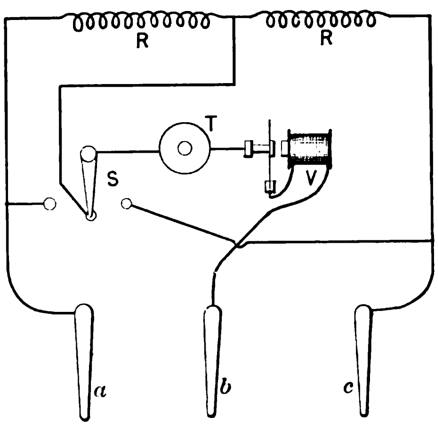


FIG. 2.—DIAGRAM OF CONNECTIONS.

It is evident that the current used for testing is the railway current flowing through the rails, and variations of this will not affect the preliminary testing results except when the switch happens to be thrown from one side to the other at the same instant that the current in the rail changes. As this is not likely to happen often there never has been any serious inconvenience on this account. It is also evident that variations in the current in the rail will not make any difference in the final test when the switch point is on the middle button, as this is a differential test.

Francis M. Appleton.

Boston, Mass., April 21, 1900.

◆

Grounding Interior Conduits.

To the Editors of American Electrician:

Sirs:—As the National Board of Fire Underwriters rule that interior conduits "must have the metal of the conduits permanently and effectually grounded" seems to be either indifferently complied with or entirely disregarded, and as the subject, if carefully considered, would, doubtless, lead to interesting and valuable conclusions, the expression of opinions in your columns as to the reason for this requirement, how it can best be effectually accomplished, and the end in view, would be greatly instructive. Does the grounding of the neutral wire in the Edison three-wire system have any bearing on the case?

Alfred W. Watkins.

Brooklyn, N. Y., April 14, 1900.

Electrical Catechism

469. Why do electricians give so much importance to Ohm's law?

Because it is the basis of most calculations relating to electricity. It is a very simple law, but its applications are often quite complex and difficult to follow.

470. What is Ohm's law?

"The strength of the current varies directly as the electro-motive force, and inversely as the resistance of the circuit," is the form in which it was originally stated by its discoverer, George Simon Ohm, a German electrician who lived from 1789 to 1854. Using the units adopted by modern electricians, the law is: "The number of amperes of current flowing through a circuit is equal to the number of volts of electro-motive force divided by the number of ohms of resistance. This may be written,

$$\text{Current (in amperes)} = \frac{\text{Electromotive force (in volts)}}{\text{Resistance (in ohms)}}.$$

471. Is there a shorter statement of Ohm's law?

"Current equals pressure divided by resistance," or, "amperes equal volts divided by ohms." A still shorter form is to write simply the initial letters from the above equation,

$$C = \frac{E}{R}, \text{ or } I = \frac{E}{R}.$$

Although C is the natural abbreviation for current, the standard practice is to use the letter "I" to represent current.

472. What is an ampere?

The ampere (named after Andre Marie Ampere, a French physicist who lived from 1775 to 1836) is the unit of current. Defined in terms of other units, the ampere is the strength of current necessary to carry one coulomb (see Nos. 130 and 227) in one second. It is the current which an electro-motive force of one volt (see Nos. 131 and 226) will send through a circuit whose resistance is one ohm (see Nos. 224 and 232). It is the current which, passing through one centimeter of wire bent into part of a circle of one centimeter radius, would attract or repel a unit magnetic pole at the center of the circle with a force equal to one-tenth dyne. It is one-tenth of the "absolute" or "C. G. S." unit of current. It is a current which will deposit silver from a standard solution at the rate of 0.001118 gram per second. (See also No. 225.)

473. What is an ohm?

The ohm is the unit of electrical resistance. Theoretically, it is a velocity of one earth-quadrant per second; that is, the speed required to travel from the earth's equator to its pole in one second. For the practical ohm see Nos. 224 and 232.

474. How is Ohm's law used in electrical calculations?

If two of the three quantities are known, the other can be calculated easily by simple rules of arithmetic.

475. Does Ohm's law take other forms than $I = \frac{E}{R}$?

It may be written $E = IR$ or $R = \frac{E}{I}$. To illustrate, suppose in an electrical circuit in which five amperes are flowing, there is an E. M. F. of ten volts, and that the entire resistance of the circuit is two ohms. Then we have

$$I = \frac{E}{R} = \frac{10}{2} = 5;$$

$$R = \frac{E}{I} = \frac{10}{5} = 2;$$

$$E = I R = 5 \times 2 = 10.$$

476. How much current will 100 volts send through a circuit of 5 ohms?

Since current equals voltage divided by resistance, the current in this case is 100 divided by 5, or 20 amperes.

477. How much electro-motive force is necessary to send 10 amperes through 4.5 ohms?

Since voltage equals current multiplied by resistance, it requires 10 times 4.5, or 45 volts.

478. Through what resistance will 50 volts send 2 amperes?

Resistance equals voltage divided by current. Hence, in this case, resistance equals 50 divided by 2, or 25 ohms.

479. What is the resistance of a sixteen-candle incandescent lamp through which 110 volts send a current of 1-2 ampere?

Since resistance equals voltage divided by current, the resistance of the lamp is 110 divided by 0.5, or 220 ohms.

480. Does Ohm's law hold true for every part of a circuit, as well as for the whole circuit?

It does when properly applied. The pressure required to send current through any part of a circuit equals the product of the current by the resistance of that part of the circuit.

481. How does Ohm's law apply when there are several parts in a circuit?

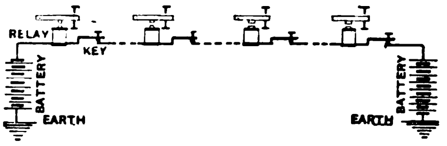
The total current equals the total electro-motive force divided by the total resistance. There may be several currents, several electro-motive forces and several resistances in the same circuit. The conditions of each circuit must be considered before applying the law.

482. What is a series circuit?

A series circuit is one consisting of several parts connected "in series" or in a row so that the same current passes through each part one after the other.

483. Give an example where several resistances are in series.

A telegraph line is a good example, the circuit consisting of the line wire, the keys and relays, the batteries and the earth return. Suppose the line consists of 100 miles of No. 8 iron wire having a resistance of 12.6 ohms per mile, 15 relays of 150 ohms each, two batteries of 50 cells of 4 ohms each and the earth return with a resistance of 25 ohms. The resistance of the line is 100 times 12.6, or 1,260 ohms; that of the relays is 15 times 150, or 2,250 ohms; that of the batteries is 50 times 4, or 200 ohms for each battery, or 400 ohms for the two. The total resistance of the circuit, allowing 25 ohms for resistance of keys and contacts, is the sum of 1,260 plus 2,250 plus 400 plus 25 plus 25, which equals 3,960 ohms, or,



SIMPLE TELEGRAPH CIRCUIT.

$$R = (12.6 \times 100) + (150 \times 15) + (4 \times 50 \times 2) + 25 + 25.$$

$$R = 1260 + 2250 + 400 + 25 + 25.$$

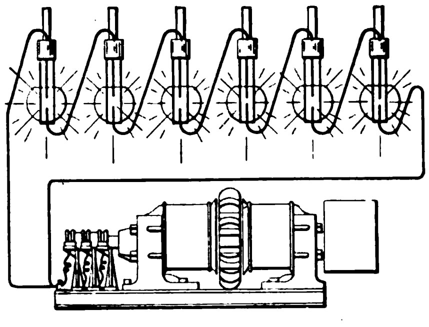
$$R = 3960 \text{ ohms.}$$

484. How can the current in such a line be calculated?

The batteries give an average of about 1.07 volts per cell, hence the 100 cells give an electro-motive force of 107 volts. The current equals voltage divided by resistance, or 107 divided by 3,960, which equals 0.027 amperes, or 27 milli-amperes.

485. Are series circuits used in electric lighting?

Arc lamps used for street lighting are generally connected in series. Those used for inside or "commercial" lighting were generally operated in this way, although it is becoming more common to operate them on multiple circuits. Each "2,000 candle" arc light on a series circuit requires about 45 volts with a current of 9.6 amperes, thus having an effective resistance of about 4.7 ohms. The circuit is made of No. 6 copper wire having a resistance of about 2.1 ohm per mile. A circuit 15 miles long with 60 arc lamps has a resistance of about 60 times 4.7 plus 15 times 2.1, or 282 plus 31.5, or 313.5 ohms; or



SERIES ARC LIGHTING SYSTEM.

$$R = (4.7 \times 60) + (2.1 \times 15) = 282 + 31.5 = 313.5 \text{ ohms.}$$

The voltage at the dynamo necessary to send 9.6 amperes through the circuit is about 9.6 times 313.5, or about 3,010 volts; or

$$E = C R = 9.6 \times 313.5 = 3,010.$$

Queries and Answers

How fast should the propellor of a small electric launch run? Is it usually geared to the motor or driven direct? S. G. B.

The smallest propeller should not make over 400 or 500 revolutions per minute, so that if a motor runs faster than this, intermediate gearing will be necessary. Ordinary speeds are 250 to 300 r.p.m. for small propellers.

How can I find the right size commutator to use on a 10-ampere, 80 volt, 150-r.p.m., four-pole, slow-speed series motor, knowing all the rest of its electrical data? W. O.

You can find the size of the commutator for your motor by allowing 1 in. of brush surface per commutator segment for each 30 amperes of output. As the current capacity of your motor is 10 amperes, each segment will require one-third of a square inch of surface area. The number of segments, of course, must be equal to the number of coils on the armature.

Will you please explain how the counter e.m.f. in a motor can be measured? A. G. S.

Measure the resistance of the armature circuit from brush to brush; multiply this by the total current passing through the armature; deduct the result from the e.m.f. of the line, and you will have the counter e.m.f. of the motor. Another method is to excite the motor fields from the line and drive it as a dynamo at its normal speed, with the brushes connected to any exterior circuit. A voltmeter applied to the brushes will show the counter e.m.f.

How can I determine the current per wire for a three-phase induction motor? For example, what size fuses would be needed for a 10-h.p. motor on a 550-volt three-phase circuit? C. A. G.

The current per wire in a three-phase motor circuit is found by the formula:

$$\frac{577 \times kw.}{E \times p \times e} = C.$$

In this formula, kw. is the output of the motor in kilowatts, E is the voltage of the motor, p is its power factor, and e its efficiency. A 10-h.p. 550-volt induction motor would probably have an efficiency of about 80 per cent and a power factor of about .85, so that the current required would be approximately two amperes per phase.

What is the extent of the vibration of an ordinary telephone receiver diaphragm? A. B. C.

The amplitude of vibration varies considerably, of course, with different voices at the transmitter end as well as with different degrees of tone from any one voice. Under average conditions when a receiver is actuated by a strong microphone current through a "solid back" transmitter the vibration of the diaphragm may be put at about 1/10,000 of an inch. It is probable, however, that an audible sound can be transmitted with an amplitude as small as $\frac{1}{2,500,000}$ inch.

What is the formula for rise in temperature of air when it is suddenly compressed? D. W. S.

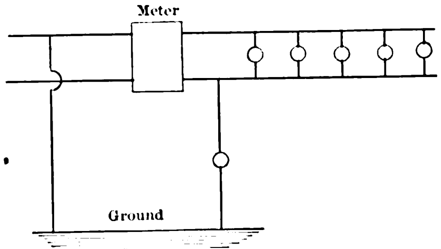
The formulas for the rise in temperature due to compression of air and assuming that none of the heat is dissipated, are as follows:

$$T \times (Rp^{.29} - 1) = \text{Temperature rise},$$

and $$T \times (Rv^{.41} - 1) = \text{Temperature rise}.$$

In these formulas, T is the absolute temperature, F. (thermometric temperature plus 461), before compression; Rp is the ratio of pressures, or the pressure after compression divided by the pressure before compression, and Rv is the ratio of volumes, or the volume of air before compression divided by the volume after compression.

If the lamp in the enclosed sketch receives sufficient current through the ground connections to burn at full candle-power will the meter register the current consumed? N. F. H.



This depends upon the type of meter used. If it is the usual recording wattmeter and the series field winding is in the lower wire of the circuit the meter will record the current consumed by the grounded lamp; otherwise it will not.

What is the advantage of using a reactance coil instead of an ohmic resistance in series with an alternating-current arc lamp? W. B. L.

The advantage is a great reduction in the actual loss of energy within the coil. A non-inductive resistance of, say, 2 ohms in series with a lamp passing 10 amperes will waste 200 watts of power. A reactance coil can readily be constructed which will have an impedance of two ohms, while its resistance is only .05 ohm. The loss in such a coil would evidently be $(C^2 \times R)$ $100 \times .05 = 5$ watts, the remainder of the impedance being purely inductive and not entailing any loss of energy.

I have in use a number of recording wattmeters which appear to be in first-class condition, including the jewels, but some of the meters run slow after the damping magnets are moved in as far as they will go. What can be the cause? J. K. S.

The trouble may be due to a bad condition of the commutator, such as the introduction of very small particles of metal between the commutator segments. Again, it may be due to the use of oil in the top bearing stud; no oil should ever be applied here because it is liable to run down on to the commutator and cause trouble there. It may be also that your top bearing stud is set so low that it introduces friction on the top collar of the shaft, or your worm wheel or train of gears may be injured in some way and thus cause the meter to run slow.

Does an arc-lamp circuit have to be supplied with 50 volts per lamp in order to start the lamps up? (2). Can two arc-light machines be worked in series on a single circuit? W. J. L.

Yes; practically. If the lamps are of the T. H. type in which the carbons remain separated when the circuit is dead, about 10 volts per lamp would start the circuit; if they are of the Brush or similar type in which the carbons are together when the circuit is dead, only a volt or two would be required for the mere starting. But if only these small e. m. fs. were applied, the current would be so reduced when the carbons separated that the circuit would go out before the regulator could raise the e. m. f. to sustain the arcs. Hence the full e. m. f. is applied for starting. (2) Yes.

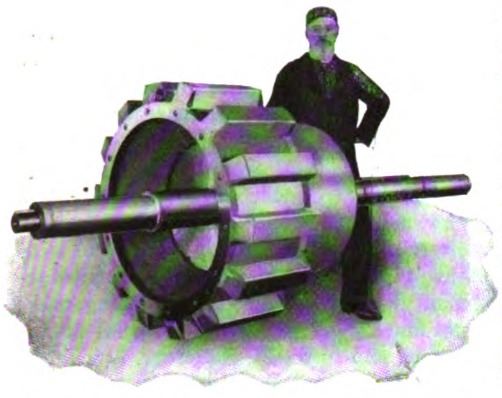
I wish to make some small storage cells, each containing one positive and two negative plates, 2 by 3 inches in size. What is the best method to follow, and what would be the proper discharge current for such cells? A. W. P.

The best method of constructing pasted storage battery plates is to use a paste of red lead and dilute sulphuric acid on the positive plate and a similar paste of litharge and dilute acid on the negative plate. You must take care that the paste is not too moist; it should be just as nearly dry as possible without being actually powdery. The negative plates do not require to be treated on both sides if you have only one positive plate in the cell; only the sides of the negative plates which face the positive plate need to be pasted. A safe rule in discharging is to allow two amperes per ounce weight of paste on each plate for a 10-hour rate, which is a convenient discharge rate. Your electrolyte should have a density of 1.2.

Is there any good reason why the main battery of a telegraph line should not be placed in the middle of the line? (2) How many storage battery cells will I need to give the same service now rendered by gravity batteries? W. M. L.

The reason the battery is usually put at the ends of the line is that with all the battery in the middle of the line a ground between the battery and either end will disable that portion of the line beyond the ground; whereas with the battery divided into two parts, one at each end of the line, a single ground will not prevent all of the stations on either side of the ground from communicating with each other. Moreover, the offices at the ends of the lines are usually the most important and it is more practical to give the batteries attention at these offices than at any of the small way stations. (2). In order to substitute storage battery cells for gravity batteries you will need just half the number of cells. Unless you are so situated that you have direct current available of suitable e.m.f. for charging the storage batteries and at a reasonable rate, it will not pay to substitute them.

IMPROVED INDUCTOR ALTERNATOR.



IG. 1.—ROTOR OF INDUCTOR ALTERNATOR.

A type of generator that is rapidly increasing in favor because of its extreme simplicity is that known as the inductor alternator. One of this class is built by the Warren Electric Manufacturing Company, of Sandusky, Ohio, and illustrated herewith. The circular frame is of cast steel, the base and sub-base are of cast-iron, and the shaft is of hammered wrought steel. The path of the magnetic lines in the circular part of the frame is axial or parallel with the shaft, instead of around the frame. The laminated projections of the stationary member are held in place between two end rings which have corresponding projections and are bolted to the cast-steel yoke-ring.

The magnetic circuit has two air-gaps, one between the teeth of the rotor and those of the stator, and the other between the smooth drum portion of the rotor (see Fig. 1) and a corresponding cylindrical sheath on the stator, shown in Fig. 2. This sheath is connected to the yoke-ring by means of six claw-shaped radial extensions, the whole being cast in a single piece. The gap here can obviously be made very short, only sufficient space for mechanical clearance being required; and as this part of the machine is perfectly rigid the mechanical clearance may be reduced to 1/64 inch all around, which would be suicidal, so to speak, in the case of an ordinary armature.

The rotor is a cylinder of cast steel, into which the shaft is fitted and forced, and upon the surface of one end projections are built up of thin annealed sheet steel. The other end is turned smooth and true, and fits into the smooth bore of the rear end of the circular frame, as already described. The cylindrical end of the rotor, therefore, revolves in an intense magnetic field, which is steady always at its maximum strength. Where the magnetic flux passes between the teeth of the rotor and those of the stator, its strength varies between the minimum and maximum, hence the necessity for the use of thin metal construction in the teeth. The rotor carries no wire, so that there is no wire in motion on the machine, consequently no commutator, collector rings or brushes are required.

There are 28 generating coils mounted on the teeth of the stator and a single exciting coil mounted around the inner end of the sheath referred to above, which projects axially into the structure, as shown. The number and stationary condition of the generating coils combine to afford a very great range in adjustment for voltages. For example, a machine of the size shown in the engravings, which has 28 generating coils, may have these coils connected up to give the full output of the machine at either 2000 or 1000 volts for use with transformers, or at either 250 or 125 volts for use without transformers; the coils may also be connected up so as to utilize half of the output of the machine at 1000 volts and the other half on an entirely different circuit at either 1000 volts or some lower figure; still again the coils may be arranged to supply several entirely independent circuits at voltages, of course, below the maximum voltage of the machine; individual regulation being obtained in such a case by means of reactive coils.

Used in this fashion the machine presents the inestimable advantage of continuous service on all other circuits in the event of the disablement of the coils supplying one of them, which characteristic is manifestly not obtainable when the whole machine winding is connected up together and the various circuits radiate from bus-bars. In fact the number of combinations which may be arranged with this stationary armature winding divided into individual coils is surprising. The machine illustrated herewith is built to give single-phase output but this type of machine is also made for polyphase work.

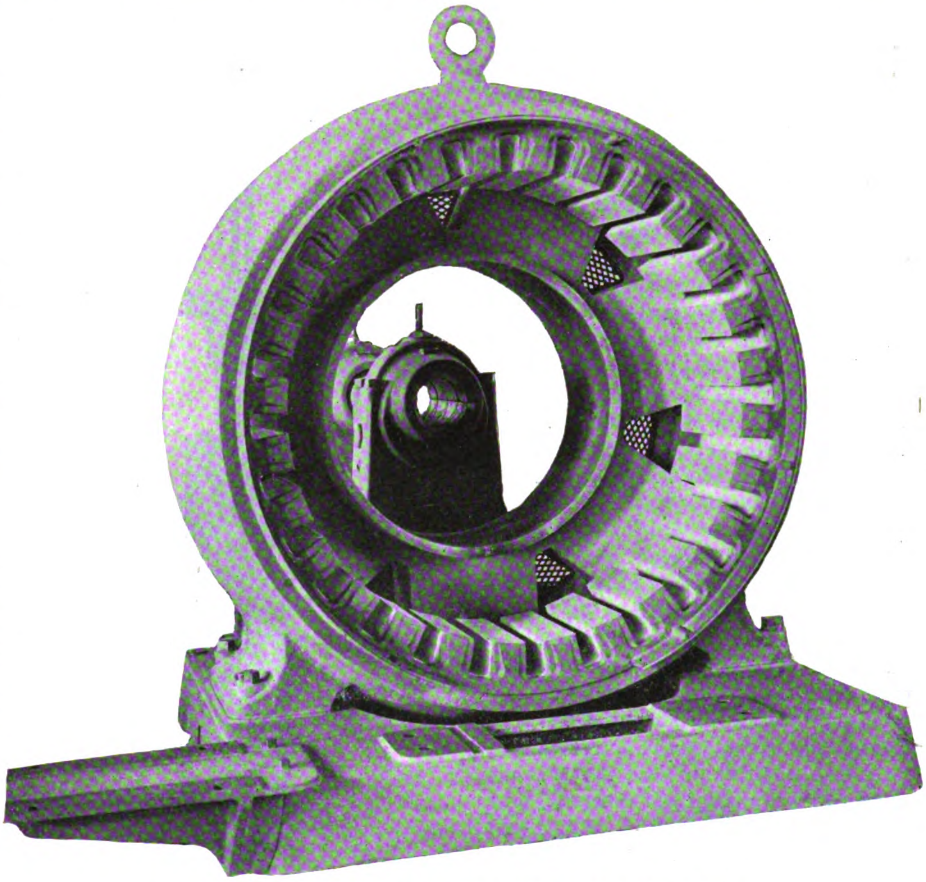


FIG. 2.—STATIONARY MEMBER OF INDUCTOR ALTERNATOR.

The greatest possible attention has been paid to the bearings of the Warren alternator, and it is confidently asserted that those used on this machine have no equal. They have been designed especially for the severe work expected of them in a machine built for practically continuous runs, in a service where stoppage from any cause occasions great annoyance and damage, frequently to entire communities. The bearings are self-aligning, self-oiling and adjustable in every direction while the machine is in motion.

PRIMARY BATTERY TROUBLES.

BY F. C. OVERBURY.

The seeming impossibility of getting two or more primary batteries to act exactly alike under apparently similar conditions is due to many causes not thoroughly understood by battery users. In the carbon-zinc types especially, this difference is very marked and the variation more serious. The carbons of one cell will be more or less porous than those of the next. The quality of carbon may differ widely even when manufactured by the same works, and with the process of moulding and pressing now in use, it is impossible to turn out every carbon exactly alike.

This difference in structure and material affects not only the current, but the voltage. The conductivity of a hard carbon is greater than that of a soft one, so that for a given resistance the surface is considerably smaller; with some electrolytes, therefore, the voltage is less when hard carbon is used than with a soft one. The quality of the carbon used affects the strength of the cell to a very marked degree, and some carbons are practically worthless for this service. The impurities of the carbon vary with different lots of a given make, and this causes difficulties that are hard to counteract.

The zinc is another weak spot in a battery and causes no end of trouble. Absolutely pure zinc cannot be made at present in commercial quantities, and the smallest amount of iron or lead present will cause local action in the battery, and gradually consume the zinc, in addition to saturating the solution with zinc salt. There is always a slight local action at the water level between that portion of the zinc below the solution and that above, the two parts acting as a couple of opposite polarities. This action is very strong if there happens to be iron or other metal present in the zinc at that point. In some cases the zinc will be eaten entirely away and drop to the bottom of the jar. Only zinc electrodes from the most reliable firms should be used, as any others are very likely to be made from scrap zinc which may contain lead, brass or iron in varying quantities. A very good way to prevent the surface local action is to paint the zinc with some good insulating material for about an inch and a half at the liquid level. The zinc will also last longer if properly amalgamated. The mercury has the peculiar effect of bringing the pure zinc to the surface, and also prevents the electrolyte from coming in contact with the impurities in the zinc. Enough attention is not paid to this highly important detail of battery maintenance.

The water used in a battery is perhaps one of the most important, and yet the least considered of any factor in successful battery-work. Many cells are filled with water that has been standing days and weeks in iron or lead pipes. The result is local action at once. The freedom from impurities in the excitant is also a most important factor. Iron is most frequently found, and in white salts can be detected by the yellowish color. The crystallization of zinc salt on the carbon and zinc is one of the greatest disadvantages of the cells using sal ammoniac as an excitant. The pores of the carbon become filled with these crystals, which increases the internal resistance of the cell, and gradually decreases the active carbon surface. In addition to this the crystals prevent the hydrogen from escaping, and gradually lower the strength of the cell until it becomes useless. These ever increasing crystals form also on the zinc, covering up the surface completely, and sometimes on the bottom of the jar, becoming so hard that jars are often broken in removing it.

This crystallization is the most serious defect inherent in sal ammoniac, and its existence is one of the principal reasons for the ready adoption of "federal salt" and "federalite" by battery users; another is the creeping of sal ammoniac. The federal salt compounds do not form any crystals whatever and the salts do not creep. When a cell using either "federal salt" or "federalite" is about exhausted, a milky substance is precipitated which washes out easily and does not affect the carbon. Unlike sal ammoniac, federal salts contain an oxidizer which absorbs the hydrogen as fast as it is formed in the carbon; the cell therefore is always ready for renewal by recharging afresh with federal salt. Such a cell rapidly recovers its original e.m.f.

A NEW ENCLOSED ARC LAMP.

An enclosed-arc lamp in which an unusual length of arc and a peculiar method of regulation are employed has been brought out by The Continental Electric Company, of Boston. Fig. 3 shows the Continental arc lamp mechanism with the outer globe and casings removed. The e.m.f. across the arc is 100 volts, or 20 volts higher than that usually employed, so that on a 112-volt constant-potential circuit only 12 volts need to be taken up by resistance outside the arc, instead of the usual 32 volts. The longer arc, it is stated, gives a gain of 12 per cent in candle-power per watt at the arc, and as the gain in watts at the arc is 25 per cent, the total gain in candle-power, for a given current, figures out at 40 per cent. The longer arc also possesses the advantage of a smaller percentage of shielding by the lower carbon, as compared with the usual length of enclosed arcs.

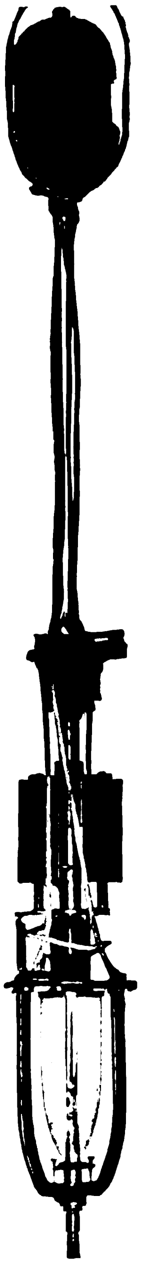


FIG. 3.—CONTINENTAL ARC LAMP.

The method of regulation consists of providing an inductive or reactance coil, shown at the upper end of the hanging stem, and connecting this in parallel with the regulating magnet. This arrangement is said to make the regulating magnet much more sensitive to current fluctuations, and to result, therefore, in a much steadier arc than could be obtained without this arrangement. The current passed by the lamp on a 112-volt circuit is 4½ amperes.

WALRATH GAS ENGINE.

The practice of governing gas and gasolene engines by throttling the charge is becoming more and more general as the resulting decrease in weight per unit of output becomes more fully appreciated. Engines governed by missing explosions must be heavy enough to distribute the energy imparted to the piston by one explosion over three or more revolutions (six or more strokes), according to the load, whereas a throttling engine is not required to store up energy for more than three strokes, no matter what the load may be. Another means of lessening the weight of the moving parts and the shock imparted at each explosion is to provide two cylinders, so that an impulse is given to the crank-shaft once every revolution. This practice has become standard as regards engines of considerable output.

One of the most recent exponents of the practice, above outlined, is the Walrath engine, built by the Marinette Iron Works Manufacturing Company, of Marinette, Wis. Figs. 4 and 5 are sectional elevations of the engine, and Fig. 6 an external view, showing the arrangement of the valve and firing-rods. Fig 4 also shows the details of the igniter and firing-gear. The secondary shaft is driven through an intermediate spur-gear, and carries a "snap" cam, which raises the firing-rod gradually and allows it to drop suddenly, giving a quick, sharp break at the igniter terminals, the igniter being electric. The operation of the exhaust valve is shown clearly by Fig. 5.

The gas and air are mixed in an external chamber, located back of the cylinder, and equi-distant from both, as shown in Fig. 6. Regulation is effected by throttling the admission of the explosive mixture. The governor is of a familiar type of shaft mechanism, the radial motion of the weights toward and away from the shaft being transmitted to the throttling valve through links, levers and a bell-crank. The quality of the explosive mixture, that is, the proportion of air to gas, is adjustable by means of a valve, the stem of which projects through the top of the mixing box, and has a crank-lever mounted on it.

The crank-case is closed, and contains lubricating oil, which is applied profusely to the working parts by the "splash" method. It is stated that this furnishes ample lubrication to the plunger eliminating the necessity for a special cylinder lubricator. These engines are also built in single cylinder form in small sizes and with four cylinders in the large sizes, the two-cylinder type here shown being the intermediate size of engine.

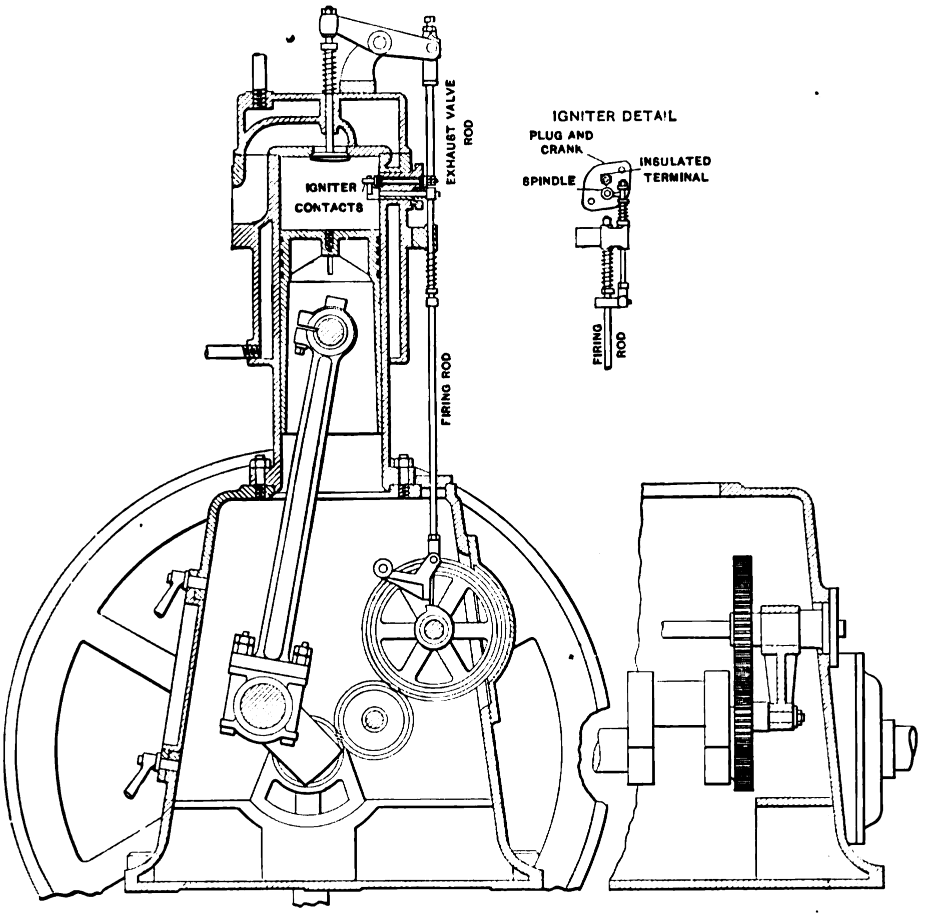

IGNITER
CONTACTS
EXHAUST VALVE ROD
FIRING ROD
IGNITER DETAIL
PLUG AND CRANK
INSULATED TERMINAL
SPINDLE
FIRING ROD

FIG. 4.—SHOWING IGNITER GEAR.

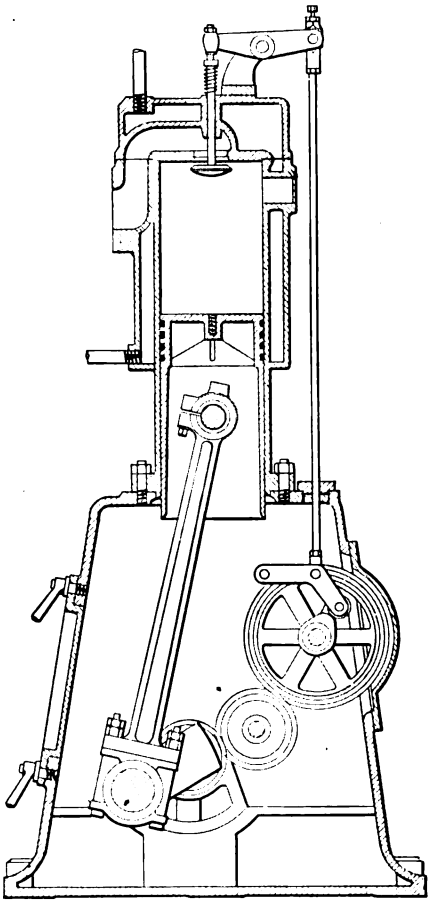


FIG. 5.—SHOWING EXHAUST VALVE GEAR.

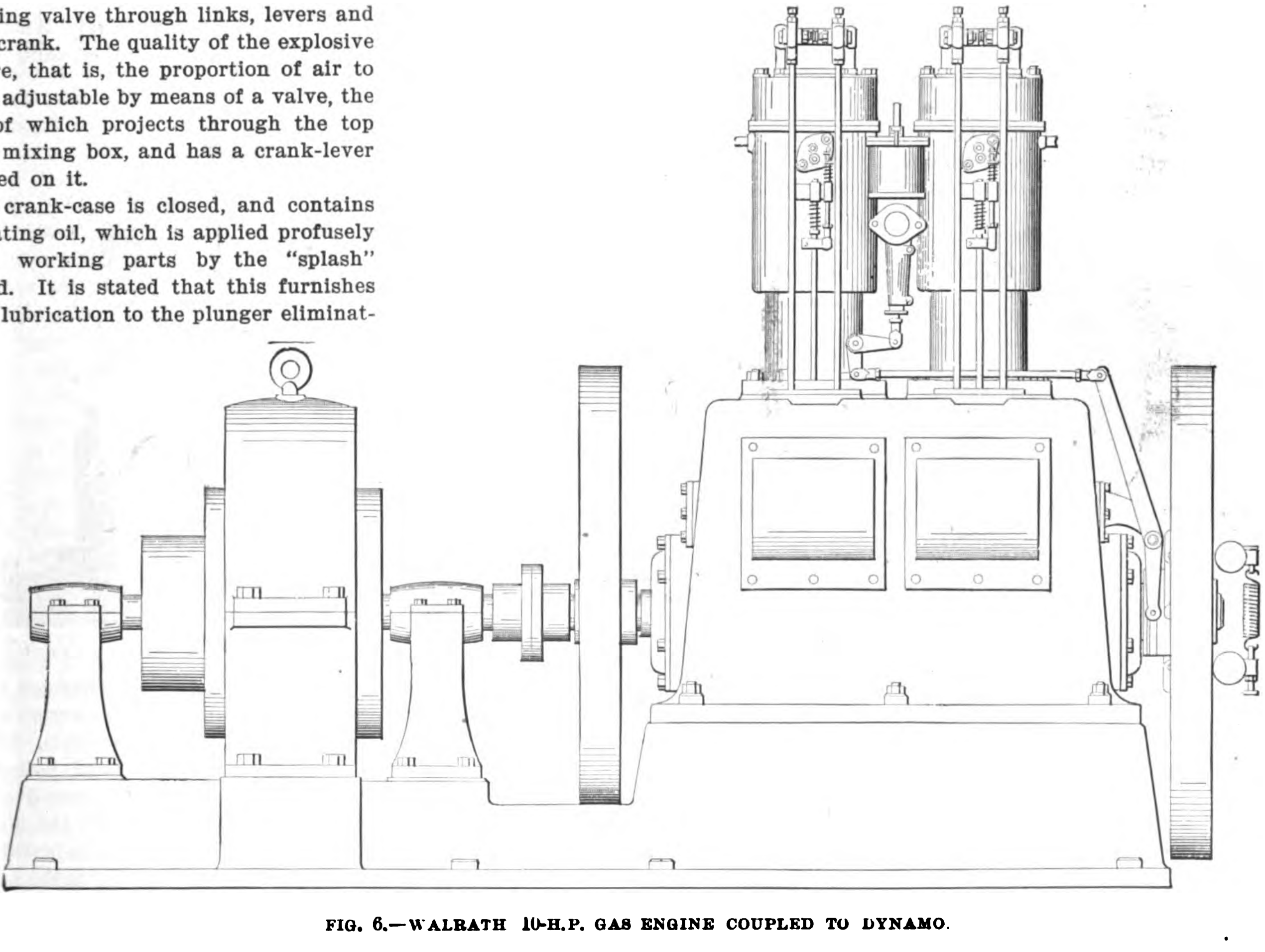


FIG. 6.—WALRATH 10-H.P. GAS ENGINE COUPLED TO DYNAMO.

New Apparatus and Appliances

THE ARGUS LIGHTNING ARRESTER FOR TELEGRAPH LINES.

The Argus lightning arrester, represented by Fig. 1, and manufactured by Foote, Pierson & Co., New York, is a somewhat radical departure in the telegraph instrument field, both as to design and principle of operation. The arrester consists of a porcelain base having two grooved sections around which bare copper wire, No. 14 B. & S. gauge, is wound spirally, and a ground plate extending the entire length of the coil and adjacent to it, the terminal of which is in the center of the plate. The spiral coil acts as a choke coil and forces the lightning to pass from it to the ground plate, the discharge being divided up between several gaps. The distance between the coil and the ground plate gradually diminishes as it nears the center of the arrester, giving different air-gap lengths so as to extend the range of the instrument. One of the most important features claimed for this arrester is that while it is effective it does not ground or disable the line and does not require cleaning of any plates or readjustment after a storm. The arresters being made entirely of porcelain and brass, present a neat and clean appearance and give the line upon which they are used a much higher insulation than some of the old types of arrester.

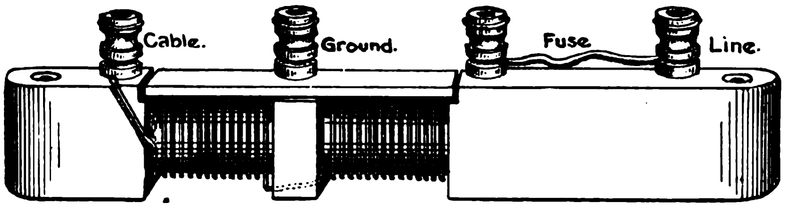


FIG. 1.—ARGUS LIGHTNING ARRESTER.

NEW MAIN LINE SOUNDER.

J. H. Bunnell & Co., New York, have recently brought out a greatly improved type of main-line telegraph sounder that contains several new features. The notable point of novelty is the mechanical adjustment of the distance between the armature and the magnet cores. This is accomplished by an eccentric movement operated by the upper adjusting nut, which causes the arch in which the armature is pivoted to slide up or down in its guides. The arrow on the adjusting nut indicates at a glance the relative position of armature to magnet. The adjusting nut is also provided with a projection (not shown in the cut) by means of which the operator can tell as soon as he takes hold of the adjusting nut which way to move it in order to get the desired adjustment. It will be noticed that the screw and the check nut that are ordinarily used on the front end of the armature lever have been dispensed with, a simple steel pin being inserted in the lower side of the lever to strike the anvil. When the indicating arrow on the adjusting nut points straight downward the armature is as close as possible to the magnet cores, and they can never come into actual contact. One of the annoyances of the old form of main line sounder, or relay, was the breaking of the string that is used to hold one end of the retractile spring of the armature lever. In the new form the use of string or cord is entirely dispensed with and a wide range of quick adjustment is secured by means of a cam lever operated by the lower adjusting nut. It will be observed that both adjustments are operated from the front of the instrument, thus making it more convenient to adjust whether mounted in combination with a key on one base or separately on a table or in a resonator box. The quickness with which adjustments can be made is noteworthy. The instrument has been designated the "M. C. M." (1900) model and is furnished with either a brass or an aluminum lever, and with or without a key on the one base, as desired.

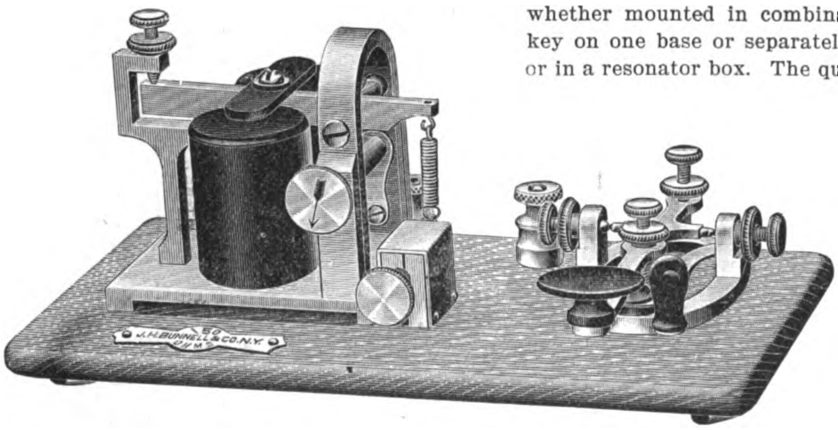

J.H.BUNNELL & CO.N.Y.

FIG. 2.—NEW BUNNELL MAIN LINE SOUNDER.

COMBINED SWITCH AND FUSE BLOCK.

The accompanying illustrations, Figs. 3 and 4, represent a new double-break knife-blade switch and fuse carrier manufactured by Johnson & Morton, of Utica, N. Y. Fig. 3 shows the device complete, but with the circuit opened, and Fig. 4 shows it with the fuse carrier removed. This fuse carrier, of porcelain, slides between the two pillars; depressing, it forces the single blades or clips on the base in between the double clips or jaws on the carrier, closing the circuit through the fuses. For re-fusing the carrier, it is removed from the pillars, as shown in Fig. 4, after removing the guard screws at the top ends of the pillars. All conducting parts are made of pure spring copper, and the contacts are liberal and well fitted. The fuse is practically enclosed by a shield, and yet so thoroughly ventilated that it will interrupt a short-circuit without damage to the fuse holder or the operator. All binding screws are provided with knurled nuts, having screw-driver slots, so they can be tightened either by hand or with a screw-driver. All the current-carrying parts are of solid pressed copper, and no milled or soldered connections are used. The fuse carrier is made of especially tough porcelain, to withstand any amount of hard usage. The whole device is very simple and substantial, and is about one-half the size of a fused knife switch. It is especially useful where space is important, and also enables inexperienced persons to replace fuses without chance of injury or damage.

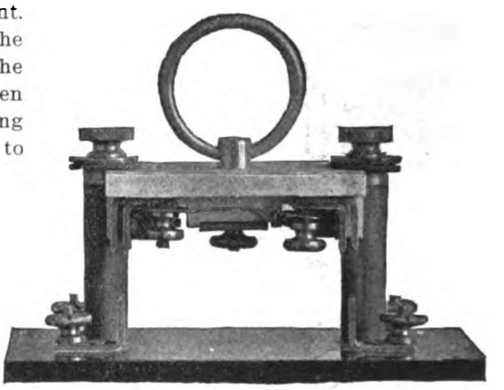


FIG. 3.—SWITCH WITH CIRCUIT OPENED.

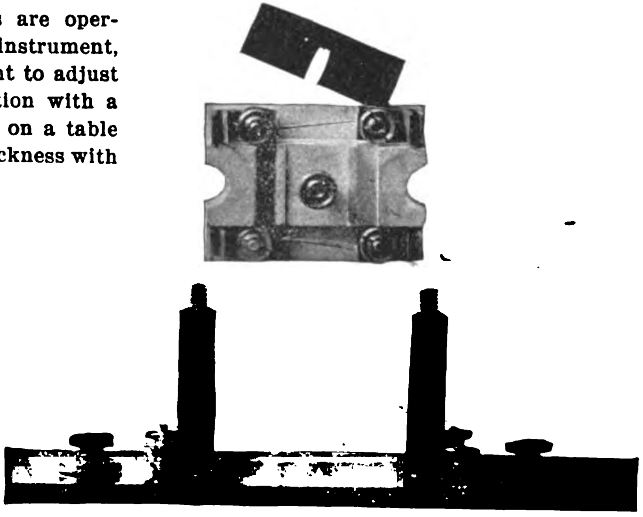


FIG. 4.—SWITCH WITH FUSE CARRIER REMOVED.

CHAPMAN VOLTAGE REGULATORS AT THE ARMOUR PLANT.

The large Armour power plant described in the May issue of this paper includes in its switchboard equipment three Chapman voltage regulators for controlling the alternating-current e.m.f. Fig. 5 shows one of these machines in a case; in the Amour plant they were mounted directly on the switchboard. Each regulator consists of three essential parts, a resistance to be inserted or removed from the field circuit of the generator to be regulated, a working solenoid to do the work of inserting and removing the resistance step by step from the circuit, and an auxiliary relay solenoid to determine the movement of the working solenoid. The resistance is made of german silver coils, units of the enamel resistance type, or carbon. Ample carrying capacity is provided so the resistance will not heat to any extent. This resistance is connected to a series of copper segments placed in a horizontal row, and having a contact slider arranged to move over their surface. The contact slider is operated mechanically by the moving core of the working solenoid. The working solenoid consists of two differentially-wound coils placed on a brass tube, one at each end of the tube; the middle portion of the tube is left vacant. Inside of the tube is fitted an iron plunger somewhat shorter than the distance through the two coils. At the center of the plunger a rod is attached which passes out through a longitudinal slot cut in the vacant portion of the tube. The contact slider above mentioned is attached to this rod and so moves with it and the plunger. In order to prevent too quick a movement of the plunger a very simple retarding device is used. The iron plunger is hollow and the rod in its center has a valve which can be adjusted by turning a knob on the end to which the contact slider is fastened. The brass tube is closed at its ends and completely filled with oil. The movements of the plunger toward either end can take place only as it displaces the oil and causes it move through the hollow plunger. The rapidity of the movement can be very finely adjusted by means of the valve. The force tending to move the iron plunger depends on the balancing of oppositely-wound coils against each other, and the balancing is determined by the action of the small auxiliary solenoid whose only work is to cause one or another of two platinum pointed screws to make contact with the brass lever supporting its core. Contact with one screw causes perfect neutralization of the differential coil at one end of the working solenoid and so disturbs the balance and causes the plunger to move toward the other coil. And contact with the other screw causes neutralization of the coil at the other end and a movement in the opposite direction.

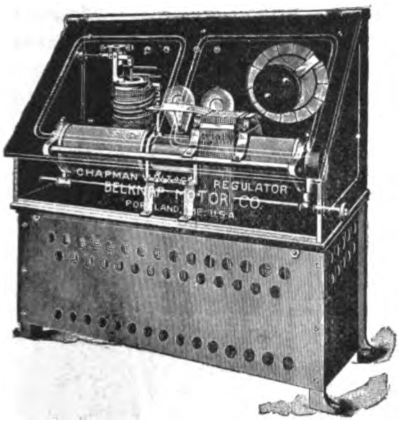


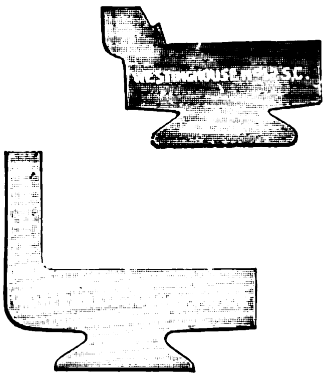
FIG. 5—CHAPMAN REGULATOR.

The small solenoid may be wound to suit the demands of station regulation. It may have simply a fine winding to be connected as a shunt across the lines to be regulated and in this case it will secure constant-potential regulation at the point of attachment to the line. Or it may be wound with a fine winding as before and also with a coarse winding, the fine winding connected as a shunt to the line and the coarse one in series with the line. In this case it will regulate for constant potential at some distant point on the line which may be predetermined by the setting of an adjustable compounding switch provided as a part of the regulator. Or, again, the small solenoid may be wound with a single coarse wire in series with the load, in which case it will secure regulation for constant current on the line. But whatever the nature of the regulation, the small solenoid will perform its duties with an accuracy as close as 1 per cent. above or below the normal, and is adapted to either direct or alternating-current circuits. Alternating currents are especially capable of close regulation by this instrument as the slight jar incident to its flow through the small solenoid almost entirely eliminates the element of friction at the pivot of the lever supporting the core, and it will easily recognize a change of ½ volt on a 110-volt circuit.

COMMUTATOR SEGMENTS.

Van Wagoner & Williams Hardware Company, of Cleveland, O., has engaged in the manufacture of drop-forged copper commutator segments, two forms of which are shown by Figs. 6 and 7.

These bars are made from the best grade of lake copper.



FIGS. 6 AND 7.

CARR COMMUTATOR TRUER.

The Akron Electrical Manufacturing Company of Akron, Ohio, has brought out the new Carr commutator truing device illustrated by Fig. 8. This tool is built on the engine lathe principle and is directly attachable to any machine having a removable bearing cap, with the great advantage that the armature does not have to be removed from the machine. It is possible to complete the work in less time than it takes to remove even a small armature. It is stated that as the work is done while the shaft is running in its bearings, the face of the commutator runs absolutely true. It is further stated that lack of rigidity and consequent chattering and gouging in of the tool have been entirely obviated, so that when the commutator is dressed off, a slight application of No. 00 sandpaper will give a perfectly finished commutator. The tool is adjusted to the desired cut by means of the cross feed; this cut should invariably be light, several light cuts being taken in preference to one heavy one. The feed should also be slow, as a smoother job is thus obtained. For the best work a commutator speed of from 200 to 250 feet a minute will be found desirable; in the case of large machines this can generally be obtained by slowing the source of power, and often with small sizes also. A crank for attachment to the pulley is provided so that the machine may be operated by hand if necessary, but it is desirable to use a power drive because of its more uniform speed. The device is built in two sizes: Type A, for commutators up to and including 20 ins. in diameter and 12 ins. face; Type B adapted to commutators up to and including 48 ins. in diameter and 18 ins. face. However, the design of the generator enters largely into the range of the tool and in some cases it will be considerably in excess of these figures.

At any rate, the two machines will cover any ordinary range of work, and a great deal that is considerably beyond the limitation of what might be reasonably termed "ordinary" work, so far as the size of the commutator is concerned.

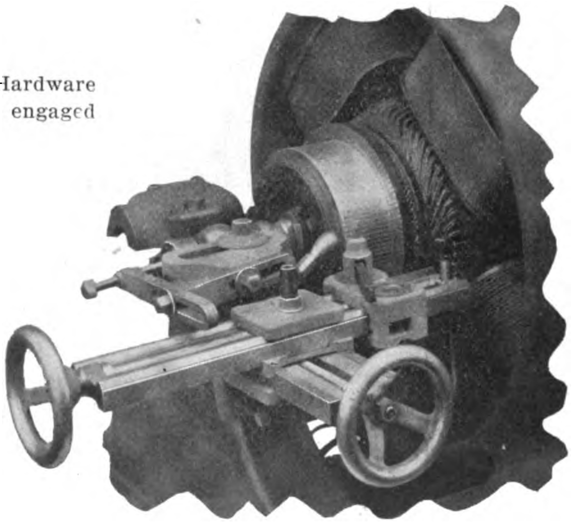


FIG. 8.—COMMUTATOR TRUING MACHINE.

GROUND CONNECTION AND BUSHING FOR METAL CONDUITS.

The "Seco" ground connection and bushing, manufactured by the Specialty Electric Company, of Brooklyn, N. Y., are represented by Figs. 9 and 10, the former showing the device and the latter its application. This ground connection and bushing are designed to meet both the requirements in the latest rules of the National Board of Fire Underwriters which specify that "metal conduits, where they enter junction boxes, and at all other outlets, etc., must be fitted with a capping of approved insulating material, fitted so as to protect wire from abrasion"; and "must have the metal of the conduit permanently and effectually grounded." To meet the first requirement, a neat, substantial, insulating bushing is fitted to the end of the conduit by means of collar, as shown in Fig. 9. The second requirement is met by connecting together the wires from the different conduit ends at each junction box, outlet box, etc., as shown in Fig. 10, thus bonding together all the conduits throughout a building and making one earth connection sufficient to permanently and effectually ground the entire conduit system.

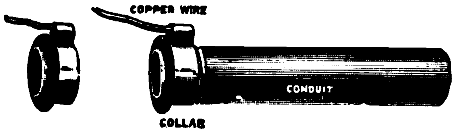


FIG. 9.—"SECO" CONDUIT BUSHING.

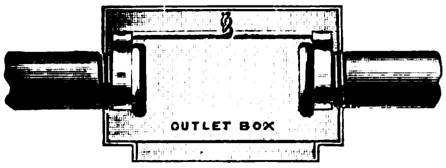


FIG. 10.—BUSHING APPLIED.

It is supposed by some that the iron conduits in a building are necessarily grounded, but this is a most unwarranted assumption. The metallic continuity is broken at each outlet, cut-out box, etc. (particularly with enameled conduits, the enamel being an insulating substance). The apparent ground is usually caused by wet plaster in new buildings, and generally disappears when the plaster dries, or else remains on part of the conduit system only.

COMMERCIAL ENGINE-TYPE GENERATORS.

One of the engine-type generators built by the Commercial Electric Company of Indianapolis, Ind., is represented by Fig. 11 and its armature by Fig. 12. The machine has a substantial and graceful frame of cast steel which affords protection to the magnet coils and armature, yet does not obstruct the ventilation. The field coils are wound on spools by which they are protected from injury and are made easily removable. The field cores are of circular cross section, giving the smallest possible length of a turn of the field coils, and are provided with pole-shoes. The builders state that less than one per cent. of the output is required to magnetize the field of of a 75-kw. machine. The armature is of iron-clad type with "barrel winding," by which means the fewest possible number of joints and bends are made in the conductors, and mechanical rigidity and ample ventilation are secured. The conductors are rectangular copper bars formed into coils and individually insulated, and an additional insulation is applied to the slot; each coil is tested as it is put in place in order to thoroughly guard against grounds. The windings are so proportioned that the field magnet is relatively strong compared with the armature; the pole-pieces are so shaped and the armature teeth are worked at such a density that the crowding of the flux to one pole tip under load is prevented; these features combine to secure a fixed commutation point. Mechanical solidity of the armature is secured by the use of complete discs punched in one piece instead of discs made up in sections. The commutator is of large size and carbon brushes are used throughout. The company's new brush-holder with a flexible conductor connected to each carbon is used exclusively on these machines, which are catalogued as "Type L. D."

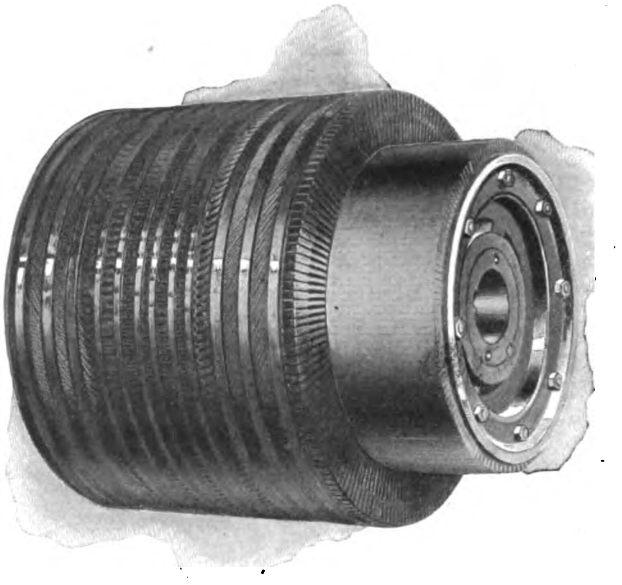


FIG. 12.—ARMATURE OF ENGINE-TYPE GENERATOR.

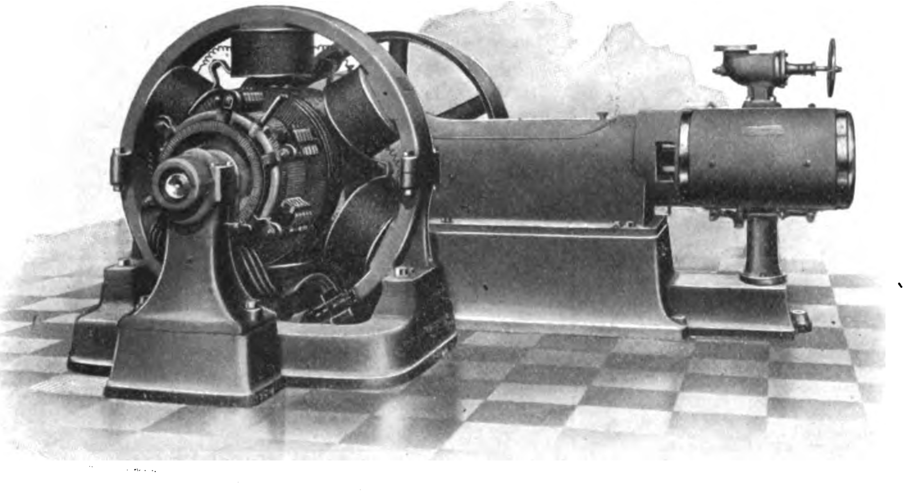


FIG. 11.—COMMERCIAL ENGINE-TYPE GENERATOR.

ROBBINS & MYERS DESK FAN.

The propeller type fan made by the Robbins & Myers Company, of Springfield, Ohio, and shown by Fig. 13, is known as the Searchlight Fan, from the fact that the motor body is so mounted in a swivel trunnion frame that its beam of air can be directed to any part of the room while the base of the motor remains stationary.

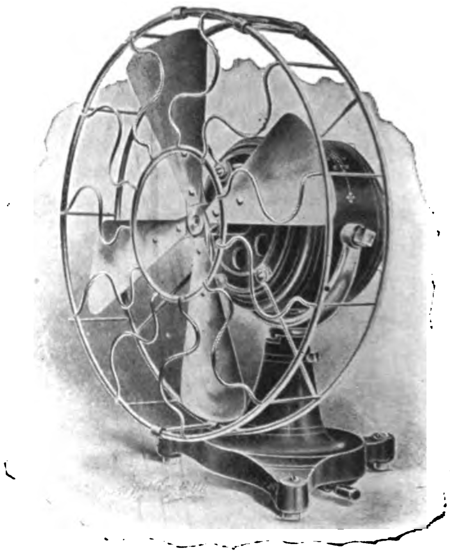


FIG. 13.—SEARCHLIGHT FAN MOTOR.

In general design this motor is very similar to the Standard ceiling fan, described in the May number of this paper, the same form of brush holder being used. The commutator construction is similar, as is also the arrangement of pole pieces and coils. Lubrication is effected by grease, fed from covered brass grease cups by vibration wire feed. The use of solid lubricant prevents the dripping and spreading of oil which catches dust and makes a desk fan unsightly after a few days' run.

The speed controller is of entirely new design. The resistance coils are made of high-resistance wire wound in a single layer on an asbestos tube surrounding a cast-iron holder from whose surface the heat is radiated. This cast-iron coil-holder is fastened by three arms to a heavy porcelain switch plate and has journaled on its lower face a cast-iron switch lever which carries on one end a spring-brass contact piece, arranged to slide over five switch points. The whole controller is fire-proof and practically indestructible and the makers claim it to be absolutely non-sparking.

The guard for 1900 is of a novel pattern, made entirely of brass, and so designed as not to depend on either solder, screws or twisted wire joints for its solidity.

MOVABLE TOOL TABLE.

A most convenient shop appliance, shown by Fig. 14, is being made by The New Britain Machine Company, of New Britain, Conn. This is a metal table mounted on casters and designed to hold tools, small castings and finished pieces of the class that usually litter up a work bench and frequently get lost in a scrap heap. The convenience of having small tools constantly at hand, which is provided for by making the table mobile, is obvious, as is the superiority of a metal receptacle over a wooden one, which not only splinters, but becomes oil soaked. The table is also equally convenient for holding screw-machine tools, lathe tools, or, in fact, for use at any machine, and is well adapted for assemblers' use because of its portable feature. It is made, however, without casters if desired, and can be furnished of a height to pass underneath a lathe, where it will be out of the way and at the same time convenient for the lathe man. The dimensions are 20 ins. x 26 ins. x 32 ins. high, and the weight is 175 lbs.

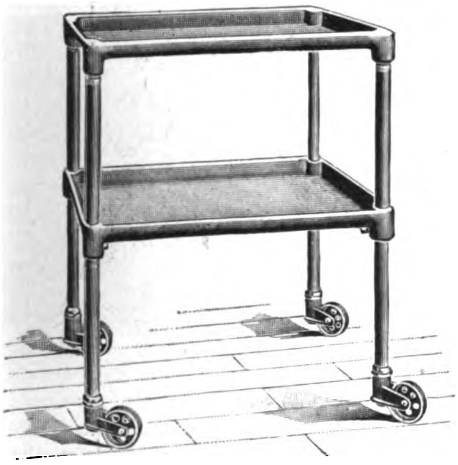


FIG. 14.—MOVABLE TOOL TABLE.

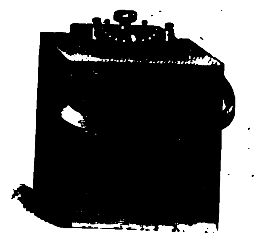


FIG. 15.—EQUIPMENT WITH RHEOSTAT.

NEW SURGICAL LAMP AND BATTERY OUTFIT.

The Brooklyn Electric Lamp & Novelty Company, Brooklyn, N. Y., is manufacturing small incandescent lamps and batteries for surgical and dental work which embody several new features. The lamp holder is a tube of black glass on the end of which a hood of clear glass is blown after the lamp and its connections are in place. Fig. 16 shows a straight and a curved holder, each with its lamp complete. The use of glass as a holder is regarded as an important feature, as it results in a perfectly antiseptic structure. A white enameled reflector is provided behind the lamp, the advantage of which is obvious. It is stated that the glass hood which surrounds the lamp becomes only moderately warm, making the arrangement suitable for use where high temperature would be inadmissible.

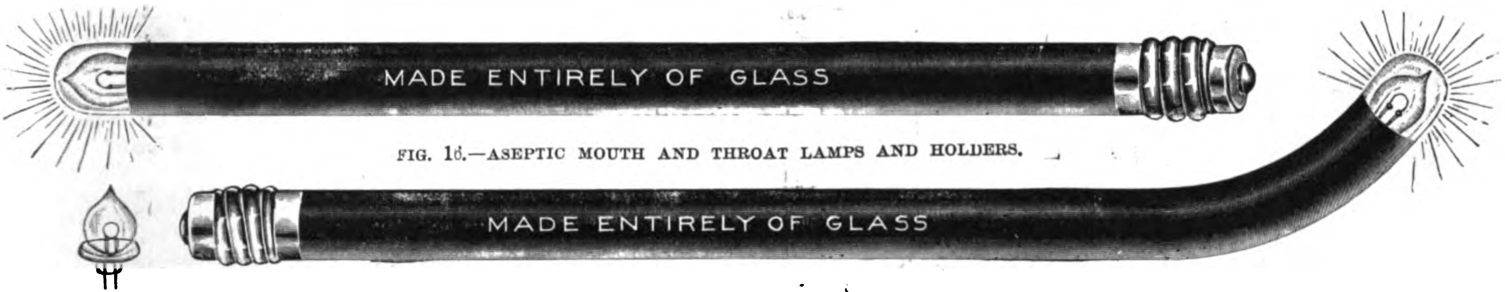


FIG. 16.—ASEPTIC MOUTH AND THROAT LAMPS AND HOLDERS.

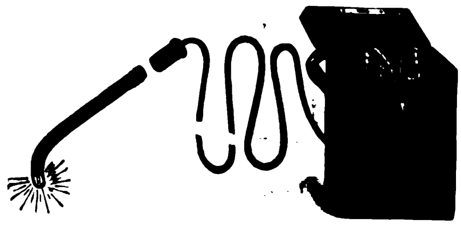


FIG. 17.—SMALL EQUIPMENT.

The rear end of the glass holder is equipped with a screw receptacle plug of the type used in connection with Edison-base wall receptacles, but much smaller. This plug screws into a rubber-insulated receptacle attached to the free ends of the flexible cord leading from the battery. No switch is necessary, a slight twist of the lamp holder being sufficient to separate the screw plug from the contact pieces in the receptacle.

The battery comprises three cells put up in a substantial case, as shown by Fig. 17. Two sizes are furnished; the smaller will give from 6 to 8 hours' actual service, and the larger is capable of 12 hours' continuous service. The cabinet contains three cells, in each size, but the larger equipment is also provided with a regulating rheostat, as shown in Fig. 15. The lamp holders and cords are put up in a neat case similar to the usual style of leather instrument case, and of such size as to be carried easily in a coat pocket.

THE BURT EXHAUST HEAD.

The Burt Manufacturing Company of Akron, Ohio, is building an exhaust head for which strong claims are made. Fig. 18 represents the interior of the head. It will be noticed that the sides of the structure are parallel throughout most of its height. The object of this construction is to give more room for steam expansion and to present a greater area of cooling surface than would be available with tapering sides.

Another feature is the use of a deflecting cone instead of a baffle plate; this, it is stated, practically eliminates all back pressure. Around the upper edge of the drum, where it joins the roof of the head, is a shield plate, the function of which is to catch the particles of oil and moisture carried by the steam, and prevent their continuing with it out at the top. The con-

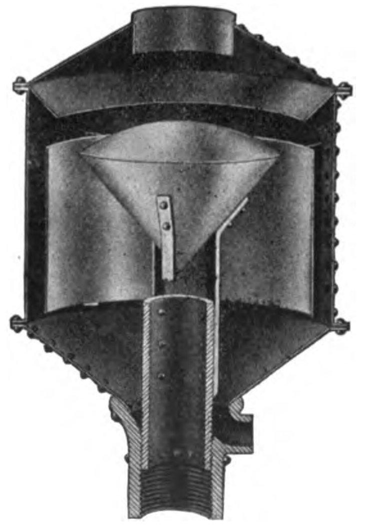


FIG. 18.—BURT EXHAUST HEAD.

densation and oil trickle down between the outer wall of the drum and the inner cylinders shown in the cut, finally discharging through the outlet on the right-hand side of the neck.

The exhaust head is made of very heavy iron, painted with anti-rust paint, and the joints are lapped, riveted and soldered. It is obvious that it cannot become overloaded or explode from accumulated steam pressure because there are no restricted passages. The manufacturers claim that the discharge at the top is dry steam and that the head is absolutely noiseless in service.

HOPPES RIGHT ANGLE SEPARATOR.

In making pipe connections for either live or exhaust steam where it is desired to use a separator or oil eliminator, it is often difficult to use the regular vertical or horizontal type of separator. This difficulty can sometimes be overcome by using a right angle separator. The one shown by Fig. 19 is manufactured by the Hoppes Manufacturing Company, of Springfield, O., and with the exception of the top portion is the same in general construction as the company's well-known steel shell separator of the horizontal type. This separator can be connected to use in either direction, as the intercepting troughs are the same on both sides. The troughs shown are kept partially filled with water and all entrainment of water or oil is intercepted and carried off through the pipes leading from the troughs to the bottom of the separator.

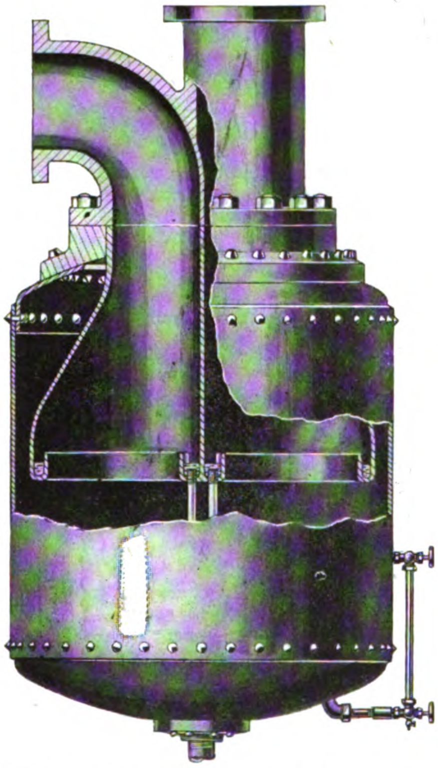


FIG. 19.—HOPPES RIGHT-ANGLE SEPARATOR.

This device will no doubt enable a separator to be used to advantage in some places where it would be very difficult or impossible to install one of the ordinary type.

PORTABLE ELECTRIC LIGHTING PLANTS.

The outfit shown by Fig. 20 is one of two complete portable electric lighting plants recently designed and built by the Frank M. Pierce Engineering Company, of New York, for Barnum & Bailey's circus. Each is complete in itself, carries its own lamps, wires and fittings in each wagon. The plants are in some respects similar to the "Buffalo Bill" plants which are now so well-known, especially in the matter of the prime movers, which are the familiar Case engines, built by the New Britain Machine Company, New Britain, Conn., for whom the Pierce Company is the general sales representative. In the plant illustrated, the engine and direct-connected dynamo of 15 kw. capacity occupy a space of only 70 cu. ft.; this is said to be the most compact combination for this output so far devised. Each outfit is capable of maintaining 25 arc lights.

The dynamos were manufactured by the C & C Electric Company, of New York; they are 15-kw. eight-pole machines, of the type described in this department last month.

The boilers have been made sectional to provide against the effect of bad feed water liable to be encountered anywhere. They were especially designed for these plants, and each is provided with variable exhaust connection, nickel-plated jacket, and all other modern improvements. Steam can be raised to 100 lbs. from cold water in six minutes after starting fires under boilers, and by means of patented devices in the way of wiring and lamp-hanging it is possible to have all lamps hung, all feed-wire connections completed, and both plants running under full load 18 minutes after the main tents are up.

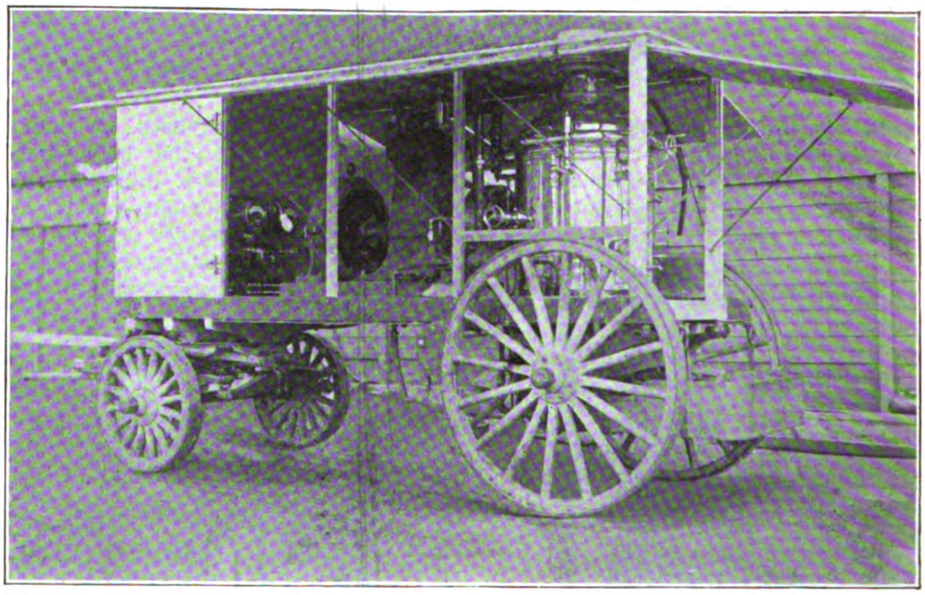


FIG. 20.—A PORTABLE ELECTRIC LIGHTING GENERATING PLANT

Both of the plants were shipped to London the latter part of February of this year, and are now being used to light the Barnum & Bailey circus in its summer tour through Germany.

GLOBE AUTOMATIC TELEPHONE SWITCH.

Figs. 21 and 22 represent a new intercommunicating telephone switch recently brought out by the Globe Telephone Manufacturing Company, of Philadelphia. Each line has a spring, the springs being arranged in two vertical rows, as shown in Fig. 22. In the center is a vertical slide having projections on each side of it which are spaced exactly to match the springs. This slide is hung from the receiver hook switch, and when the hook is down, the spaces between the lugs on the slide are opposite the individual line springs. This is the normal idle position. When one desires to call up another station, the receiver is taken off the hook, allowing the slide to rise and bring its lugs in alignment with the individual line springs; then a pin is inserted in the proper hole in the door (see Fig. 21), depressing the spring behind that hole until it touches a strip on the back of the box, connected with the general battery wire. As the spring is pressed against the call-

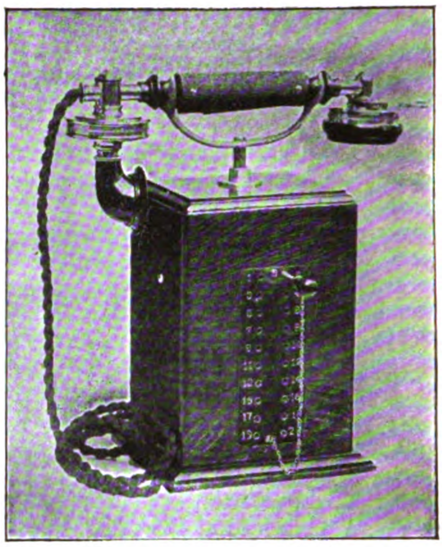


FIG. 21.—EXTERIOR OF SWITCHBOX.

ing strip it snaps past the lug on the vertical slide, and when the call has been made and the pin released, the spring comes back against the lug on the vertical slide, establishing the talking circuit. After finishing, the receiver is hung on the hook in the usual way and the vertical slide is pushed down, allowing the individual spring to come forward between the lugs, into no-contact position. It is evident that several stations may be called, one after the other, and all retained in circuit, so that messages may be sent to several stations at once, or a multi-sided conversation carried on. The springs are of phosphor bronze and the makers state that there is no liability to defective contact by reason of weakening or "setting" of the springs. The hook switch, in addition to actuating the vertical slide, performs its usual function of making and breaking the transmitter and receiver circuits.

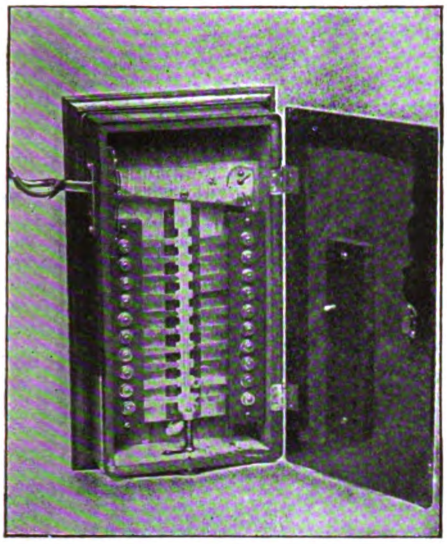


FIG. 22.—SWITCHBOX OPEN.

A DIRECT-CONNECTED TRIPLEX PUMP FOR SIAM.

The three-throw type of triplex pump is receiving marked consideration by builders of electrically-driven pumps because of the claim that the continuous discharge given by this type of pump and the consequent decreased vibration throughout the delivery system are more advantageous for the motor than types heretofore used.

Fig. 23 shows an electric triplex pump recently exported to Siam by the Stilwell-Bierce & Smith-Vaile Company of Dayton, Ohio. A common base is provided for both pump and motor, which insures absolute alignment, and renders expensive foundations unnecessary, at the same time giving compactness and solidity. The motor shaft is extended and there is mounted thereon either a rawhide, bronze or iron pinion, engaging spur gear on the motor shaft.

The necessary reduction between the speed of the motor and the speed of the main crank is thus accomplished. In cases where a special low-speed motor is employed, single reduction of gears can be had. This machine is a Smith-Vaile outside packed and outside guided triplex pump. The side thrust of the connecting rods, which has heretofore proven an objectionable feature of triplex pumps, is now accommodated at the cross-head, and is not communicated to the glands. All gears are machine cut. The operation of the pump is said to be practically noiseless. The motor is of Wagner make.

OBITUARY.

TIMOTHY M. BOSART, vice-president and business manager of the Jenney Electric Manufacturing Company, died suddenly of heart disease about 12.30 o'clock May 9. Mr. Bosart was born in Springfield, O., April 12, 1844, and was a son of Timothy M. Bosart, Sr. He went to Indianapolis in 1866 and was engaged in the grocery business for over 20 years. He then became identified with the Yaryan Fifth-wheel Company, and in 1898 was made vice-president and general manager of the Jenney Electric Company. He was a successful financier, and accumulated considerable property. He leaves a widow and five children: Oscar, twenty years of age, now a student at Purdue University; three girls and a small son.

TRADE PUBLICATIONS.

GRAPHITE. Joseph Dixon Crucible Company, Jersey City, N. J.—The May number of the bright little periodical published by the Dixon Company and devoted to its graphite interests.

COLORADO VIA THE BURLINGTON ROUTE. C. B. & Q. R. R. Company.—A finely illustrated brochure descriptive of the picturesque portions of Colorado lying along the C. B. & Q. route.

ELECTRICAL AND BRASS GOODS. Huebel & Manger, Brooklyn, N. Y.—Catalogue No. 4 of electric bells, buzzers, gongs, ornamental and plain pushes, automatic drops, strap switches, floor pushes, binding posts, etc.

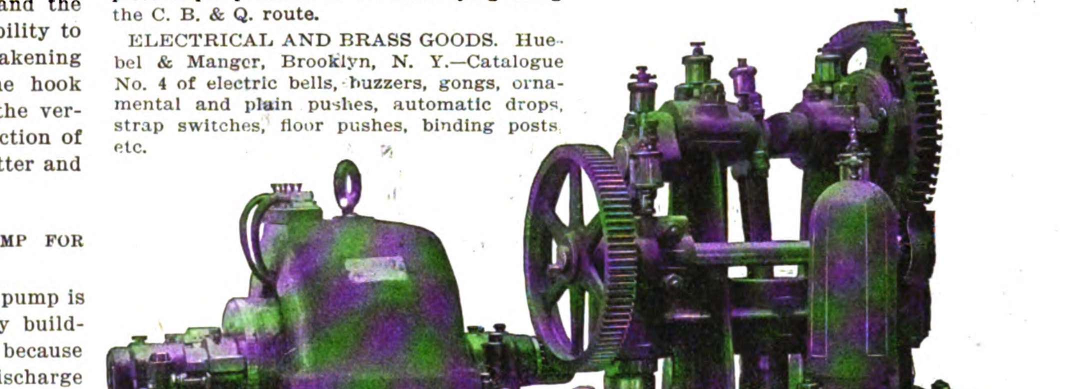


FIG. 23.—SMITH-VAILE PUMP, DIRECT-DRIVEN BY WAGNER MOTOR.

CHLORIDE ACCUMULATORS. The Electric Storage Battery Company, Philadelphia. —A bulletin constituting a reprint of an article descriptive of the installation of Chloride accumulators in the station of the Peekskill Traction Company.

CALENDAR. New York & Ohio Company, Warren, Ohio.—The regular monthly lithograph calendar advertising Packard incandescent lamps and transformers. The calendar is for the month of May, and the lithograph is unusually handsome.

DIRECT-CURRENT GENERATORS. Ft. Wayne Electric Works, Ft. Wayne, Ind.—Bulletin No. 1008, describing the latest type of Wood multipolar direct-current generators, known as Type M P, and ranging in output from ⅛ kw. to 12 kw.

DICKE BALL-BEARING WIRE REEL. Western Electric Company.—Bulletin 13, descriptive of a pay-out reel possessing the unusual feature of a ball bearing. The reel is mounted in the usual fashion on a stretcher to be carried about by two men.

ELECTRIC LOCOMOTIVE AND CRANE. J. G. Brill Company, Philadelphia, Pa.—A pamphlet describing a convenient combination of a trolley flat car carrying a crane of the jib type. The motor which drives the car is also arranged to operate the hoist.

DIRECT-CURRENT MOTORS AND BLOWER FANS. B. F. Sturtevant Company, Boston, Mass.—Bulletin H, descriptive of the well-known Sturtevant fans and electric motors mounted together in a single structure. Four types of fans are illustrated and described.

ALTERNATORS AND TRANSFORMERS. Royal Electric Company, Peoria, Ill.—A profusely illustrated pamphlet, describing in full detail the Royal inductor alternators and shell-type transformers, and containing logical arguments bringing out forcibly the many good features of the apparatus.

RAILWAY MOTOR ENGINEERING. The International Correspondence Schools, Scranton, Pa.—A pamphlet devoted to the discussion of the new course of construction in the operation of electric railway cars and machinery, recently established by the International Schools and mentioned in these columns.

MARINE GENERATING SETS. Bullock Electric Manufacturing Company, Cincinnati, Ohio.—Bulletin No. 36, descriptive of the Bullock Company's Type N 1 generators, designed for direct connection to engines for marine service. The bulletin contains com plete dimensions and data respecting the generators mentioned.

INDUSTRIAL APPLICATIONS OF ELECTRICITY. General Electric Company.—A handsomely executed pamphlet profusely illustrated with engravings showing manifold applications of electric motors to machine tools, cranes, derricks, hoists, bridges, blowers, printing presses, textile machinery, jewelry manufacturing apparatus, pumps etc.

WATCHMEN'S TIME DETECTORS. The Holtzer-Cabot Electric Company, Brookline, Mass.—Catalogue No. 29, describing Acme watchmen's time detectors, which are manufactured in two styles, one with an eight-day office clock in the same case, and the other without the time piece. These detectors may be operated either by magneto or by battery current.

PLATING DYNAMOS AND EXHAUST FANS. Commercial Electric Company, Indianapolis, Ind.—Circulars Nos. 319 and 321, describing Types B and C electro-plating dynamos and Type R direct-connected exhaust fan motors. The plating dynamos are made in six sizes, ranging from 100 to 1000 amperes capacity at 8 volts. The exhaust fans are built in four sizes from 30 ins. to 48 ins. fan diameter, in 6-in. intervals.

MACHINE TOOLS. The Garvin Machine Company, New York.—A new edition of the Garvin catalogue describing the company's well-known milling machines, gear-cutting machines, gear cutters, cutter grinders, monitor, hand and chucking lathes, profiling machines, spring coilers, etc. The catalogue is a very handy size, four by six inches, and the descriptions of the various tools are more complete and clearer than those usually found in trade catalogues.

COMPENSATORS FOR ALTERNATING-CURRENT CIRCUITS. Westinghouse Electric & Manufacturing Company.—Circular No. 1026, superseding catalogue No. 215, and describing Westinghouse Types E and F compensators. Type E compensator is designed for use in connection with a station voltmeter on circuits carrying non-inductive loads, the compensator being arranged to adjust the voltmeter for ohmic drop only. Type F compensators adjust the voltmeter for both ohmic and inductive drops and are therefore applicable to any class of circuit.

GASOLENE ENGINE CASTINGS. Lowell Model Company, P. O. Box 292, Lowell, Mass.—A catalogue of complete castings from which may be built gasolene engines of several sizes and types. The sizes of the stationary engines, which are two-cycle machines, are 1½ h.p., 3 h.p., and 4 h.p.; the sizes of the marine engines, which are also of the two-cycle type, are 1 h.p., 1½ h.p., 3 h.p., and 4 h.p. Castings for automobile engines are furnished in two styles, a 1-h.p. two-cycle machine, and four-cycle engines of 1, 2 and 4 h.p. The catalogue also includes prices on the finished engines, carburetors, mixing valves, igniter parts, propeller wheels and other accessories.

LAUNCHES AND MARINE GAS ENGINES. Rochester Gas Engine Company, Rochester, N. Y.—An attractive catalogue illustrating and describing the Rochester gas engines for launch service and some of the launches made by the company. The Rochester engine is a two-cycle machine, and up to 5 h.p. is made with a single cylinder; 7 h.p. and 12-h.p. engines have two cylinders, so that the crank shaft receives two impulses every revolution, and 18-h.p. engines have three cylinders, giving three impulses per revolution. The engines do not reverse, but a reversing clutch is interpolated between the crank shaft and the propeller shaft. The launches are built in sizes ranging from 16 to 25 ft. in length.

GENERAL ELECTRICAL SUPPLIES. Western Electrical Supply Company, St. Louis, Mo.—The company has issued a catalogue of nearly 1100 pages, with illustrations of every description of electrical apparatus from direct-current and alternating-current generators and motors down to push buttons, including all classes of street railway supplies, electric light supplies, house goods and telephone appliances. The Western Electrical Supply Company is the exclusive territorial agent for a number of the largest and best known manufacturers, among whom are Roeblings, Ohio Brass Company, India Rubber & Insulated Wire Company, Adams-Bagnall Electric Company, Emerson Electric Manufacturing Company, The Eddy Electric Manufacturing Company, Ansonia Electric Company, and Warren Electric Manufacturing Company.

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BUSINESS NEWS.

E. P. ROBERTS & CO., Cleveland, Ohio, Consulting Mechanical and Electrical Engineers, have removed their offices to the Electric Building.

THE HALL COMPOUND FEEDER COMPANY of Chicago has removed its offices from 1047 Marquette Building to No. 20 South Jefferson Street.

S. B. CONDIT, JR., & CO., Boston, Mass., have acquired the general sales agency for Elden circuit breakers, and are in a position to fill all orders promptly upon their receipt.

THE MONTAUK MULTIPHASE CABLE COMPANY, of New York, has removed its offices in the American Surety Building from the 18th to the 19th floor. The offices are now located in Rooms 5 and 6.

THE EASTERN ELECTRICAL CONSTRUCTION COMPANY of Philadelphia has removed its offices from 658 Bourse Building to 112 North Broad Street, the Fidelity Mutual Life Building.

THE SPRAGUE ELECTRIC COMPANY, New York, recently sold to the Benjamin Athar & Illingsworth Company two 200-kw. split-pole Lundell generators of the belted type for use in the steel works at Harrison, N. J.

STEPHENSON MANUFACTURING COMPANY, Albany, N. Y., reports the sale of a large order of Stephenson bar belt dressing for export to Russia and also states that this dressing is extensively used in Mexico and Argentine Republic.

THE SPECIALTY MANUFACTURING COMPANY, Indianapolis, Ind., has just completed a large shipment of Triumph belted exhaust fans to Moscow, Russia, and has booked a number of orders for shipments of water-motor desk fans to Delhi, India, and to Paris.

E. V. BAILLARD, New York City, Manufacturer of electrical instruments, models, etc., has removed to the Fox Building, Franklin Square, in order to more promptly take care of his rapidly increasing line of work. Mr. Baillard has added considerable machinery to his old plant.

THE MOUND TOOL & SCRAPER COMPANY, St. Louis, Mo., manufacturer of improved tools for scraping valves, journal bearings, etc., calls attention to its offer to give a Louvine packing tool free with each order to all readers of the American Electrician during the current month.

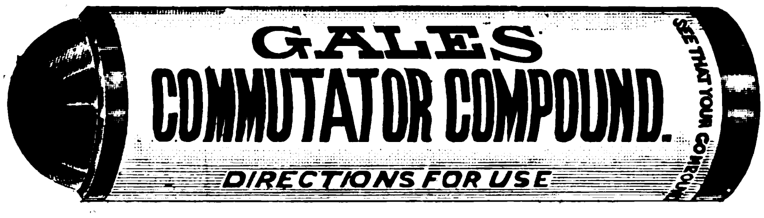
THE DESHLER-McALLISTER PHOTOMETER TAKES A MEDAL.—The Franklin Institute of Pennsylvania has awarded the Edward Longstreth Medal of Merit to the inventors of the Deshler-McAllister photometer, manufactured by the Electric Motor & Equipment Company, of Newark, N. J.

THOMPSON, SON & CO., dealers in new and second-hand machinery, of New York, have established a branch house in London, England, at 39 Victoria Street, in order to facilitate the handling of their rapidly growing export business. The London branch will be under the management of Mr. W. H. Merriman.

CURTIS J. HARRINGTON has been appointed manager of the Sales Department of the General Equipment Company, Camden, N. J., manufacturer of magnetic circuit-breakers. Mr. Harrington was formerly connected with the Morris Electric Company of New York, whom he represented in the New England territory.

THE ELECTRICAL ENGINEER INSTITUTE OF CORRESPONDENCE INSTRUCTION, New York, has removed from 120 Liberty Street to its new quarters at 240-242 West 23d Street. The growth of the Institute has been so rapid that the old quarters some time ago became inadequate to meet the demands for space.

A COMMUTATOR NECESSITY.



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American Electrician.

Vol. XII. New York, July, 1900. No. 7

ELECTRICAL EQUIPMENT IN MINING SERVICE.

ELECTRIC HAULAGE AT THE EUREKA MINES; WINDBER, PENN.

BY A. S. M'ALLISTER.

The modern coal mine bears little resemblance to its predecessor. Increased demands for fuel have required increased rapidity in the methods of handling coal, while business competition has necessitated increased economy in mine operation. The results are that the miners' pick is giving way to machine cutters and the mine mule is sharing the fate of the street-car horse.

In the selection of equipment for mechanical mine operation there enter three factors requiring careful consideration. The first and most important is that of reliability of service; second, flexibility of system; third, cost of equipment and maintenance. At the Windber, Penn., mines of the Berwind White Coal Mining Company can be found one of the most extensive and modern soft coal mining equipments in the world, and here the three requisites just mentioned have been secured by means of electrical and mechanical equipment. Although only two years have elapsed since the first mine was opened, the daily output has reached almost 10,000 tons. The mines are known as Eureka Nos. 30 to 38, inclusive. The coal lies in what is known as the Miller seam, which at that locality has a thickness somewhat less than 4 ft.

As far as is economically possible, all handling of the coal is done by machinery. Power for operating the mines is derived from batteries of Sterling boilers located at each mine. Capell ventilating fans are driven by steam engines. Ingersoll-Sergeant compressors supply air at 75 lbs. pressure for operating the pumps and coal cutters; 550-volt locomotives are used for haulage, and current from this circuit is used also for lighting the power

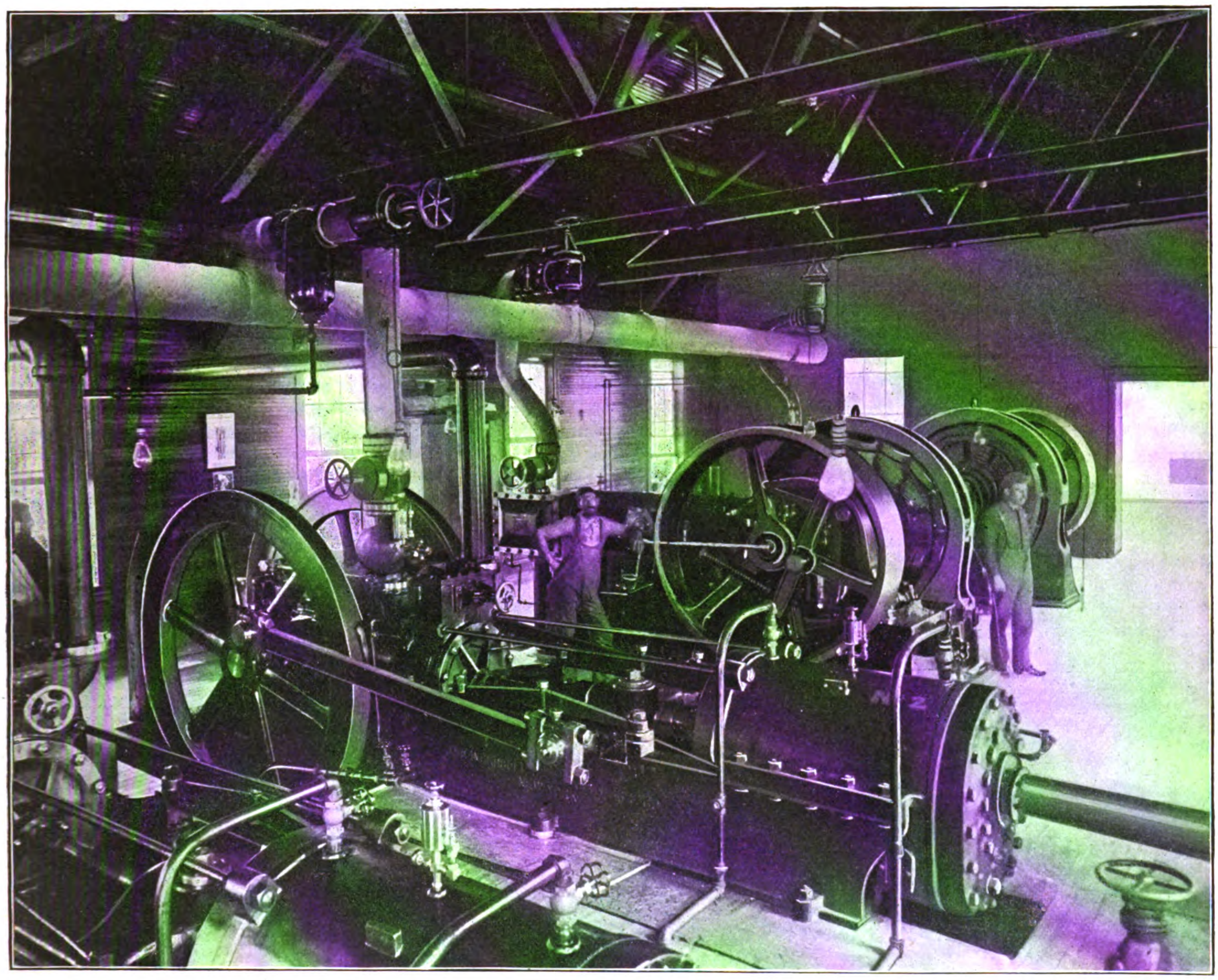

FIG 1.– ONE CORNER OF THE GENERATOR ROOM AT EUREKA MINE NO. 33.

houses and tipples as well as the mine proper. The Phillips tipple equipment used here is the latest type of self-dumping apparatus.

Where the boiler house is situated near the drift mouth, the direct use of steam engines to drive the ventilating fans, avoiding double transformation, possesses obvious economical advantages and this plan is followed. For driving pumps compressed air has been found to give entire satisfaction. Air pumps require an extremely small amount of attention, and an accidental stopping results in nothing more serious than freezing up. Air coal-cutters are used because they are capable of withstanding all kinds of usage at the hands of inexperienced operators and possesses the additional advantage of supplying fresh air at the face of the coal working.

In comparison with electric cutters, air machines are more wasteful of coal and more expensive to supply with power; moreover, pipe lines for compressed air are expensive to install and are usually found unfit to transfer to new openings after having been in use for some time. It was thought, however, that the great reliability of operation and the ease of control by untrained hands more than compensated for these disadvantages.

The first power equipment for electric haulage at Eureka No. 30 included two General Electric 150-kw. 550-volt generators belted to two 242-h.p. McEwen engines. Increased developments soon rendered a third generating unit necessary, and a 150-kw. Thompson-Ryan dynamo was installed. The resistance of the series coils of this machine being much greater than that of the series circuits of the General Electric generators, part of the Thompson-Ryan coils were left outside the equalizer circuit, only as much as were required to equal the resistance of the series circuits of the G. E. dynamos being included between the equalizer connection and the brush. Though of doubtful utility when applied to an ordinary compound-wound generator, this method has given good satisfaction with the machine mentioned. This arrangement is more clearly shown in Fig. 7.

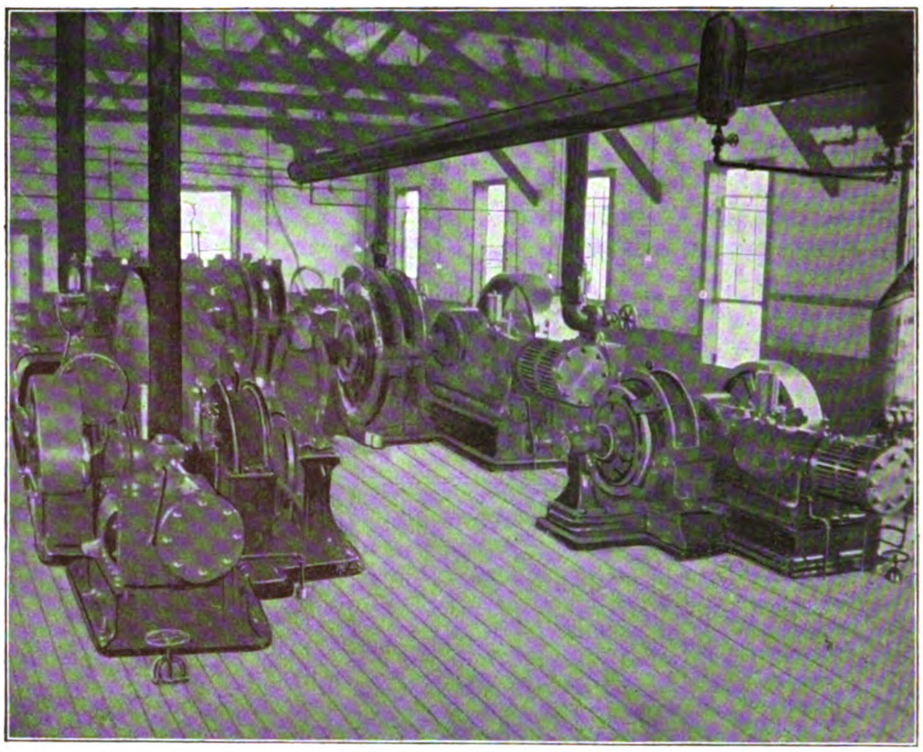

FIG. 2.—GENERATOR ROOM AT EUREKA NO. 35.

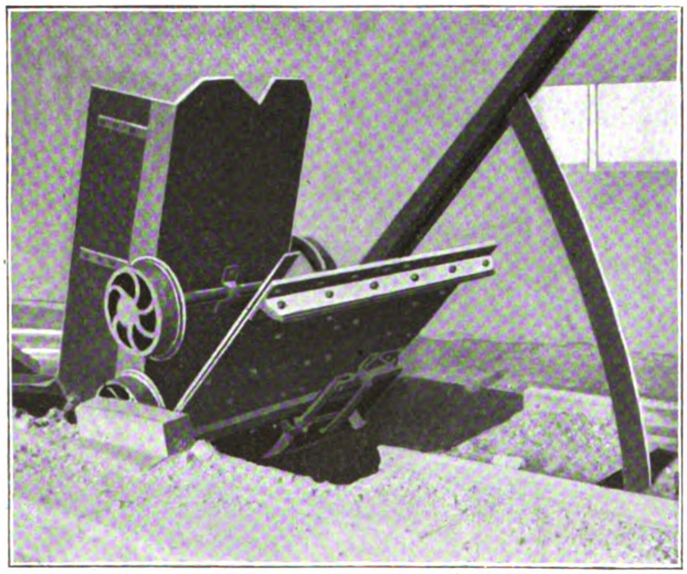

FIG. 3.—PHILLIPS SELF-DUMPING TIPPLE.

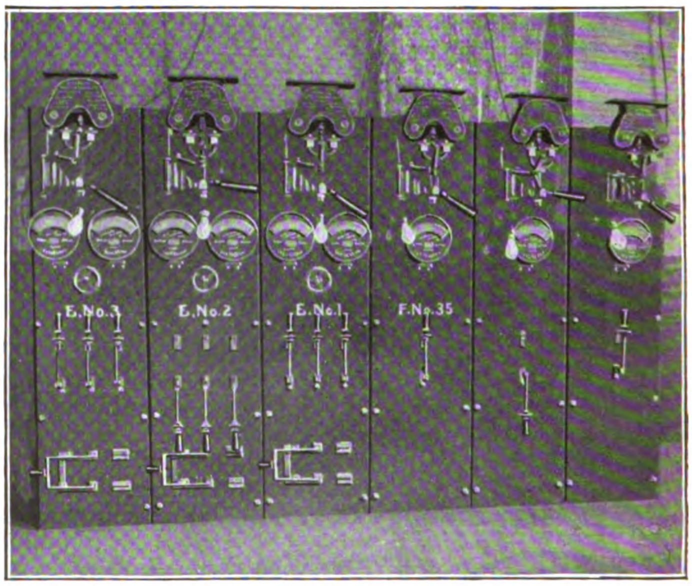

FIG. 4.—SWITCHBOARD AT EUREKA NO. 35.

When Eureka No. 31 became sufficiently developed to justify the substitution of electric for mule haulage, a power line was constructed to that mine from No. 30, a distance of 5340 feet. With a view to future use of the material No. 00 hard-drawn bare copper wires, similar to those in the mines, were used for the transmission circuits.

Eureka No. 32 is situated 6,900 feet from No. 31. Though this mine now has its own power plant, it was considered economical in its earlier existence to transmit power from No. 30. The resistance of the circuit was about 1.67 ohms; one positive wire being run from No. 30 to No. 32 and the negatives from No. 32 **connecting to the two negatives to 30 from 31. Though even the maximum short-circuit current at No. 32 could be but little in excess of 300 amperes, it was ascertained that the line was amply sufficient to supply power for one locomotive. Running on this high resistance was but little** worse than the use of several sections of the rheostats, as is necessary with the locomotives at the other mines. On account of the intermittent character of the work of each locomotive, the use of two of them at No. 32 caused very few delays **on the part of either, though only one could be using current at any given time. Each motorman could easily determine by the brilliancy of the headlights when the other locomotive was in use.**

The establishment of a power house at Eureka No. 32 **eliminated this arrange-**

ment. It contains two 150-kw. 550-volt General Electric generators direct-connected to McEwen engines. When these units were installed the number of locomotives in use at No. 30 and No. 31 had so increased as to over-burden the three generators at No. 30, so No. 32 was depended upon for assistance. By short-circuiting a portion of the shunts to the series coils of the generators at No. 32 so that they compounded from 500 to 550 volts at full load instead of from 500 to 600 as when first set up, and by altering the transmission circuits so that No. 32 was connected to No. 31 directly through a pair of No. 00 conductors, a fairly satisfactory supply of power for No. 31 was obtained when the generators at No. 30 and No. 32 were operated in parallel.

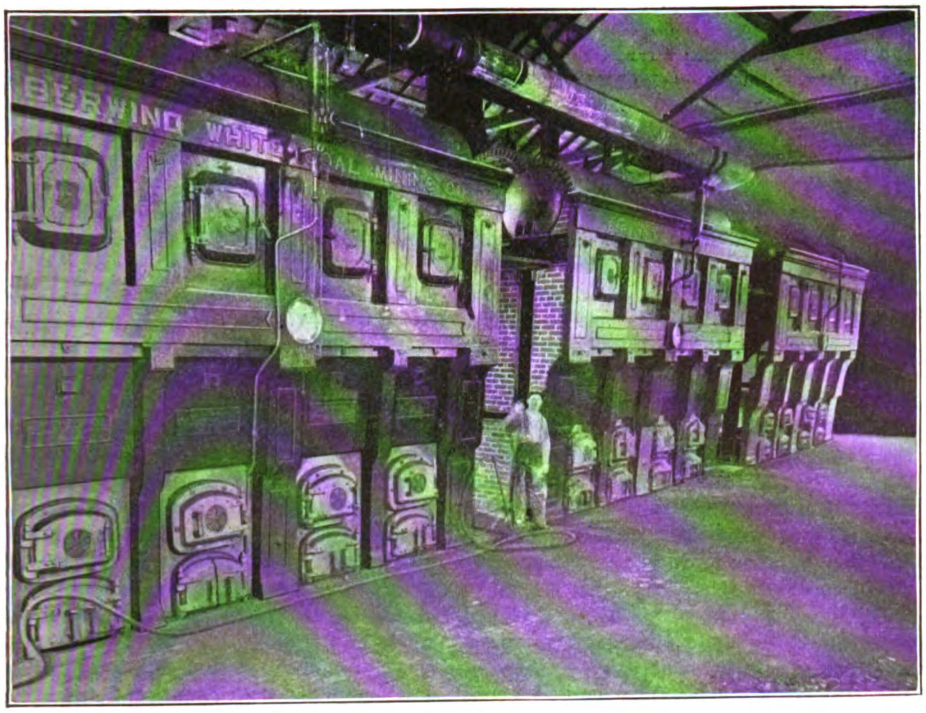

FIG. 5.—BOILER ROOM AT EUREKA NO. 35.

As now connected the resistance of circuit from No. 31 to No. 32 is 1.07 ohms. With a circuit resistance of .4 ohm between No. 30 and No. 31 and the two power plants running at the same bus-bar voltage, any demand for current at No. 31 is met by the power plants in a somewhat greater proportion than the inverse ratio of these resistances, provided neither No. 30 nor No. 32 mine is using current at that moment. By decreasing the compounding of the generators at No. 30 from 500-550 to 500-525 volts a most satisfactory service for No. 31 has been secured.

Quite noticeable in this method of paralleling compound-wound dynamos is the fact that, all other conditions being the same, one generator running at No. 32 supplies more current to No. 31 than both generators do when running connected in parallel.

Power for electric haulage at Eureka No. 35 is developed by three Thompson-Ryan 150-kw. direct-connected generators. In the early stages of the development of No. 35 a transmission line was run from No. 32, which line now is used only when it may be economical to run only one of the plants. The two plants cannot be run together as is the case with Nos. 30 and 32. Eureka No. 36 is supplied with current from No. 35.

Power for Eureka No. 34 is transmitted over four No. 00 conductors a distance of 2540 ft. from Eureka No. 33, where are installed two 150-kw. Thompson-Ryan direct-connected generators. By setting the generator circuit-breakers at 475 amperes it is practicable to supply sufficient power to run four locomotives at the two mines with either generator. Some idea of the nature of the demand for power for electric mine haulage may be gained from the fact that, though each locomotive will require, as a maximum, over 300 amperes, 475 amperes will be adequate ordinarily for four locomotives, and six locomotives will seldom require over 600 amperes.

At Eureka No. 37 have been installed two Thompson-Ryan 150-kw. direct-connected generators, and provision is made for a duplicate equipment. The locomotives at Eureka No. 38 will be driven by power transmitted from No. 37.

As has been intimated, No. 00 hard-drawn copper is used for trolley wire. The line construction throughout is of the most substantial nature. In all cases, however, due regard has been had for the fact that numerous changes of location are necessary, as the coal bed becomes worked out. Soldered trolley wire clamps are unsuited to this class of work. Only those providing purely mechanical means of gripping the wire have been found to give satisfactory service.

The locomotive trolley poles must be of such a length as to be easily reversible on a single-track entry, and this sets a limit to the height of the trolley wire outside the mine. The external wiring is supported 7½ ft. above the rails through cap-and-cone insulators by 1¾-in. pipe and pipe hangers. The side poles are set 20 ft. apart on each side of the track and 3½ ft. from the rails. To these the pipes are secured by means of cast iron side brackets held in place by ⅝-in. x 3½-in. lag bolts. See Fig. 6.

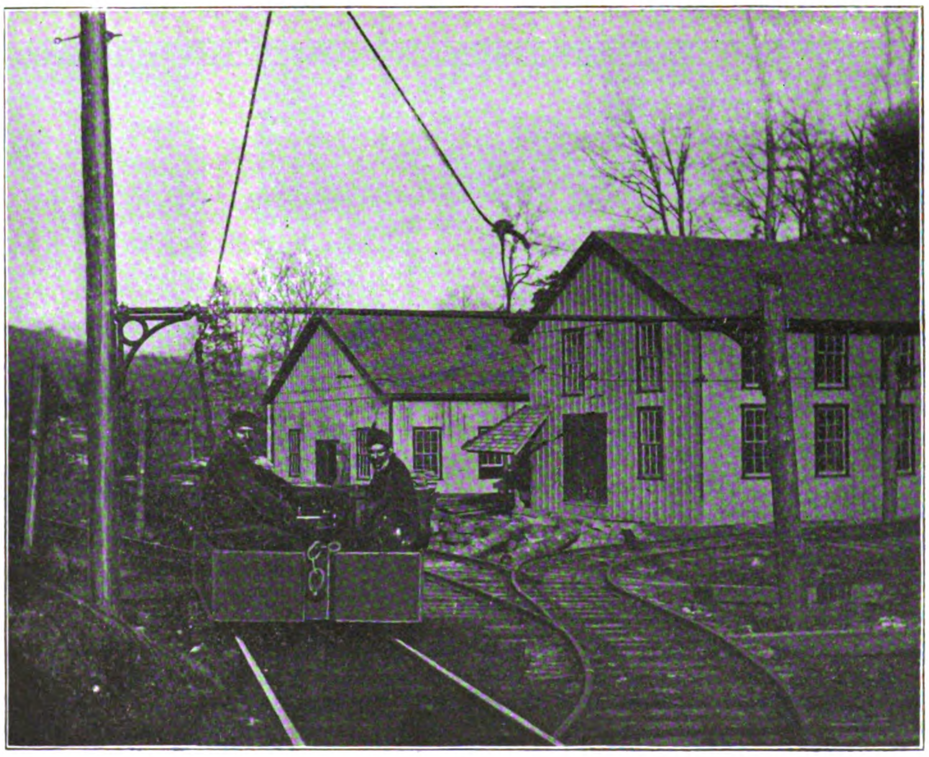

FIG. 6.—VIEW SHOWING PECULIAR OVERHEAD CONSTRUCTION.

Inside the mine the wire varies in height from 39 in. to 7½ ft. The most satisfactory method of suspending the wire from the roof is by means of cast-iron wedges and bolts. For this purpose there are drilled in the roof 1 9/16-in. holes, 6 ins. deep, spaced about 20 ft. apart on straight track and 12 ft. on curves. In these holes ¾-in. x 7½-in. bolts with hexagon heads are secured by means of two roof wedges. Each wedge has a concave inner surface to surround the bolt and convex outer surface to fit the side of the hole when driven home.

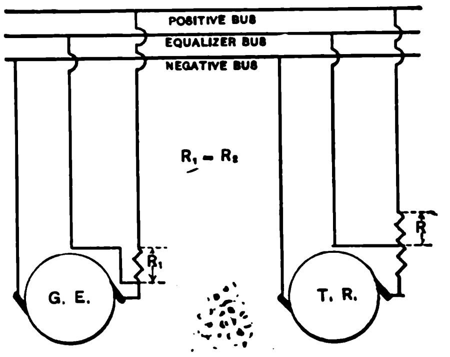

FIG. 7.—SPECIAL EQUALIZER CONNECTION.

The end of each stretch of wire is securely anchored to a special form of roof bolt through a strain insulator and turnbuckle. The use of 18-in. turnbuckles has rendered unnecessary any auxiliary tools for obtaining the required tension upon the wire.

At the air passage overcast on each side entry there is placed a section insulator and switch for disconnecting this section of wire from the rest of the mine in case of accident or extension of the trolley line. Though many types of section insulators were tested none was found which, when exposed to the accumulating moisture of the mine, would not allow the current to leak across in sufficient quantity to render the handling of the partially-insulated wire at least disagreeable, if not dangerous. Application of the scheme of opening the insulator switch and connecting the trolley wire to the rail removes all trouble from leakage currents and has an additional advantage of securing safety from an accidental closing of the switch.

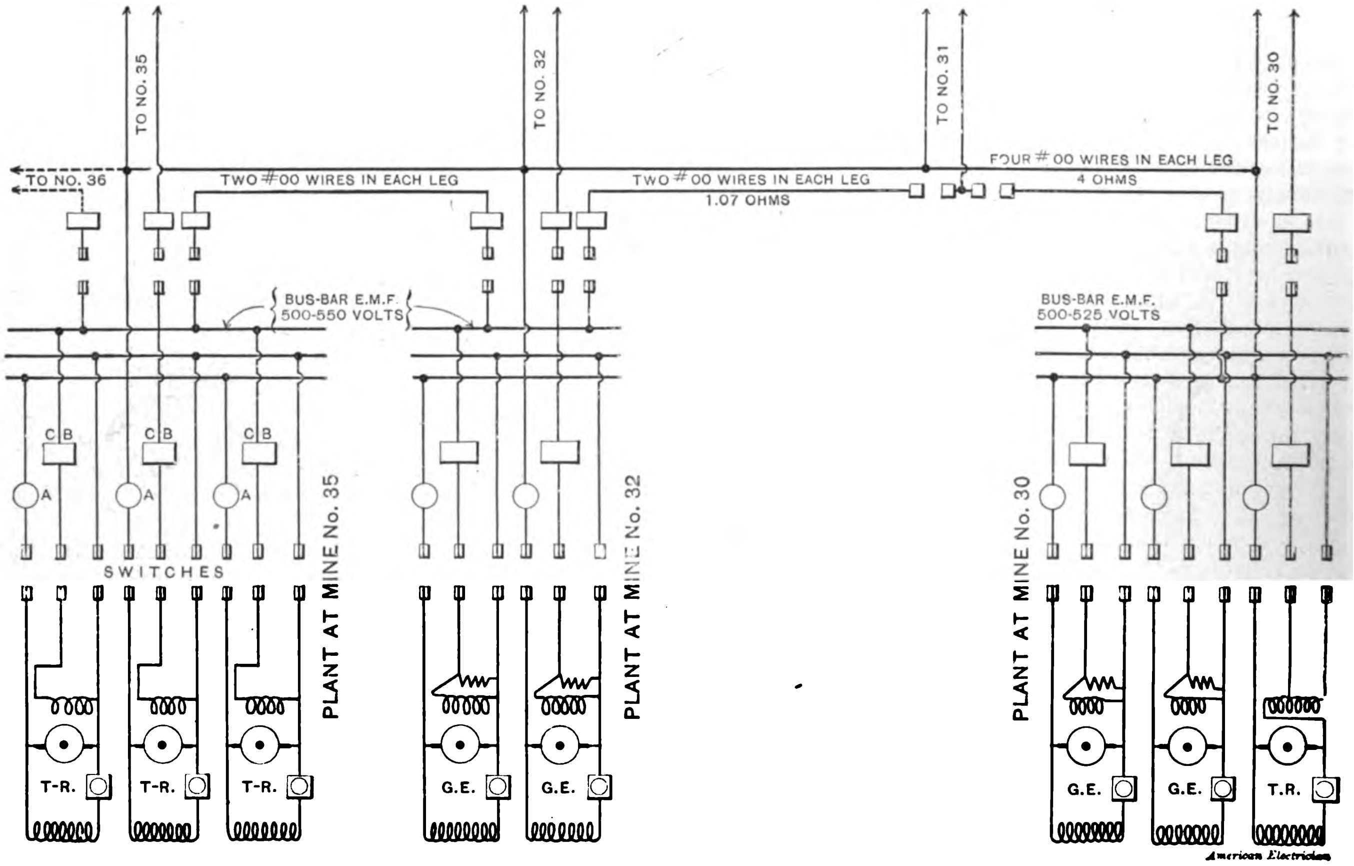

FIG. 8.—DIAGRAM OF ELECTRICAL CONNECTIONS BETWEEN THE THREE GENERATING PLANTS.

The tracks are laid single on the side entries and double on the main entries. The two main entry wires are interconnected at each side entry cross-over track. The large amount of conducting material in the main entry obviates the necessity of auxiliary feeders to any portion of the mines; 30-pound T-rails are used on all tracks traveled by the locomotives. On the main entries all four rails are bonded, though the bonding of one rail is considered sufficient for the side entries. The bonds are of No. 00 soft annealed copper secured to the rails by 23/32-in. channel pins. It is necessary to use the greatest care in order to obtain good bonding in this way on such a system as the one under discussion.

The effect of electrolysis is quite noticeable, especially upon the water pipes, a case being recalled where a certain section of pipe required a new union about every three weeks on account of "rust." A slight change in the channel pins by which the concave portion next to the wire could not offer a cutting surface as at present would undoubtedly decrease the number of bonds quite often carelessly sheared.

At each mine is located a locomotive house of sufficient size of shelter six locomotives, with pit space for four. The houses are heated by steam and lighted by electricity. The pits are five feet deep and well drained. A 6000-lb. Harrington chain hoist serves to handle the motors and axles when repairs become necessary.

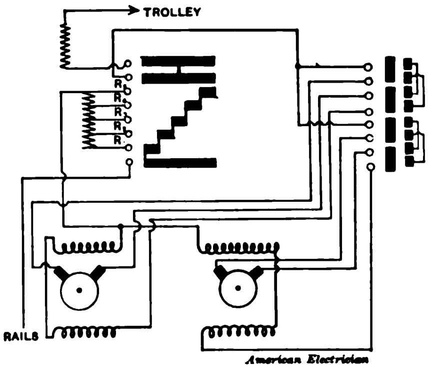

FIG. 9.—CONTROLLER DIAGRAM.

Two general types of locomotives are in use at the different mines; the General Electric 13-ton, draw-bar pull 3000 lbs. at 8 miles an hour, and Baldwin-Westinghouse, 26,000 lbs., with a speed 8 miles an hour.

All of the locomotives in use here are equipped with magnetic blow-out rheostatic controllers, the two series-wound motors of each locomotive remaining always in parallel, and the various speed changes being governed by adjustable resistance in the power circuit, as indicated by the controller diagram, Fig. 9. If it were possible always to run the trips at the maximum speed of the locomotive, this method of control for such service could not be improved upon. Experience, however, has shown conclusively that the trips can very seldom run with safety at such speed and that the major portion of the hauling is done on two of the four sections of the rheostat. Nine-tenths of all electrical trouble experienced with the locomotives at Windber has been due to this fact. A system of control so designed that the light load hauling, switching and trip gathering could be done with the motors in series and the straight track hauling with the motors in parallel would be found much more satisfactory for this class of work.

On account of the motors being always in parallel a mere shifting of the reverse lever when the locomotive is in motion results in an almost immediate stop of the locomotive, due to the generator action of the motors; this effect being independent of any connection to the trolley line. Though this action is of inestimable value when used as an emergency brake, the knowledge of its availability on the part of the motormen has rendered them more careless and resulted in the destruction of many gear wheels. Reversing the motors and throwing the controller lever to the first position has been found to give equally good braking and to have a cushioning effect on the gear wheels.

The slow speed at which much of the heavy hauling must be done has been commented upon. To return the controller lever to the "off" point with a heavy current passing, such as is required, invariably results in vicious arcing at the controller tips, which soon carbonizes the insulation. It frequently happens, even, that an arc from trolley to ground in the controller occurs, which obviously throws circuit-breakers and entails delay. In order to obviate this source of trouble the following method of using the controller has been adopted:

If it becomes necessary to throw the controller "off" on a heavy haul at slow speed, first throw the lever forward till the drivers spin, then quickly throw to "off" point. This never fails to give the desired result; that is, a reduction of sparking. The prolonged high speed of the armature generates sufficient counter e.m.f. to reduce the current to a value at which the circuit may safely be opened.

Power for lighting the mines is taken from the haulage circuit, five 110-volt lamps in series being used at the main entry cross-overs and two 275-volt lamps at the single switches. All light and signal circuits are of No. 12 insulated copper wire supported on porcelain knobs secured to wooden plugs in the roof.

There can be no doubt that, with such extensive mine operations as at Windber, polyphase currents for pumps and cutters would be found much more satisfactory and economical than compressed air. The use of 500-volt generators supplying both direct current for the haulage locomotives and polyphase currents for induction motors would, by propor disposition of circuit-breakers and fuses, prove the most economical system for mine equipments, and it seems reasonable to expect that such a plan will be adopted sooner or later.

ENGINES AND GENERATORS AT THE PARIS EXPOSITION.

BY W. H. DONNER.

The two engine rooms, French and foreign, of the Electricity Building, with their various types of machines, are gradually getting into order. The earth floor, which up to the present has been the subject of much discontent on the part of the engine builders, is being boarded over and the air is no longer filled with dry, gritty dust so prejudicial to the wearing parts of the machinery. It cannot yet be said, however, that the exhibits in this department are completed. In the French section there are still two or three unfinished engines, while several others have come to the painting stage, with parti-colored coats laid on for the purpose of selecting suitable tints. A large vertical engine in the Austrian section, built by Ringhoffer and driving a Siemens & Halske 900-kw. 500-volt generator, is yet shrouded by the scaffolding employed in installing the machine. Austria-Hungary is further represented by two engine-generator units, and these three groups, with some smaller engines and an immense Worthington pump, occupy a corner to themselves close to the Suffren boiler room, between it and the Hexagonal Hall.

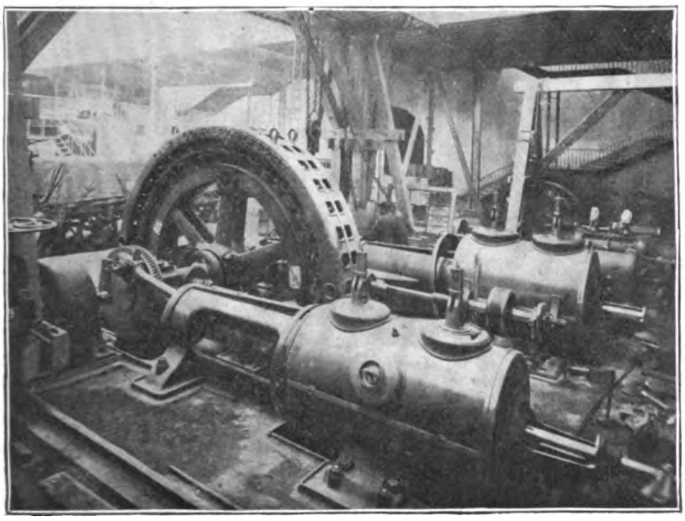

FIG. 1. CROSS-COMPOUND 1000-H P BRUNNER ENGINE DRIVING A GANZ THREE-PHASE ALTERNATOR.

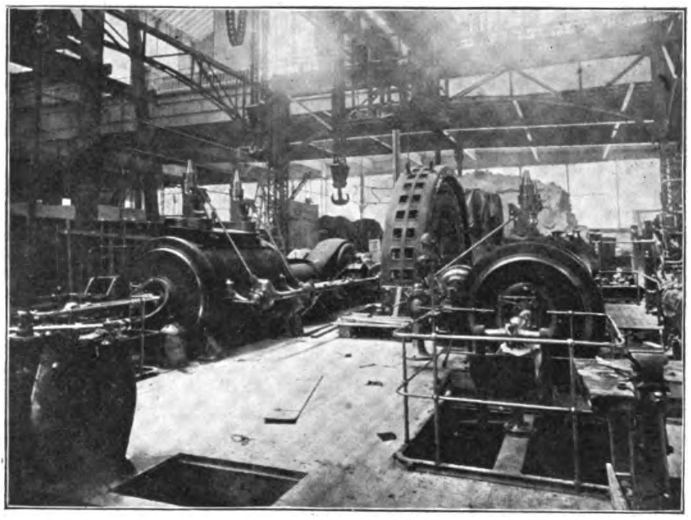

FIG. 2.—CROSS-COMPOUND 1200-H.P LANG ENGINE DRIVING A GANZ THREE-PHASE ALTERNATOR.

Fig. 1 shows a cross-compound 1000-h.p. engine built by the Erste Brunner Engine Company, driving a Ganz three-phase alternator. The somewhat unusual construction is adopted of having the exciter entirely independent and driven by a separate crank, an extension of the engine crank-pin engaging in a slot in the exciter crank. The steam cylinders are 20 11/16 ins. and 37⅜ ins. in diameter, high and low pressure respectively, and the stroke is 35 7/16 ins. The alternator has 40 poles and runs at about 125 r.p.m., furnishing current at 2200 volts and a frequency of 42 cycles per second. There is but one other generator in the whole power plant that supplies three-phase current at this frequency, a machine built by the Belgian Company of Electricity and Hydraulics, and located in the main hall of the foreign power house. The current from these two machines is brought to five transformer stations situated on the left bank of the river immediately below the Alma bridge, three-conductor armored cables being used for transmission.

Another cross-compound engine in the Austrian section is one built by Lang of Buda-Pesth, of 1200 horse-power. This engine drives its condenser air-pumps by attachment to the piston tail rods at the back ends of the cylinders. Vertically-moving Collman disc valves admit steam to both cylinders, as in the large Borsig engine in the German section; the shock of closing is obviated by the use of an oil dash-pot. The alternator, built by Ganz & Tarsa, of Buda-Pesth, furnishes three-phase current at 2200 volts and a frequency of 50 cycles a second for the illumination of a considerable portion of the Exposition buildings in the Esplanade des Invalides. The administration, with a view to guarding against any interruption of the lighting service when once it is really in operation, has arranged the machines of the two power stations in groups such that the failure of one machine will not affect the general illumination. The Ganz alternator above mentioned will feed the same circuits as the alternator by the Fives-Lille Company in the French power house, and the smaller Ganz machine will connect to the same feeder-panel on the main switchboard as the Belgian alternator of the same frequency.

Among the direct-current generators the largest are to be found in the French section, where the 1000-h.p. single-cylinder engine of Weyher & Richemond drives a Creil dynamo of 750 kilowatts output (see Figs. 2 and 3). The valve gear of this engine is peculiar, and quite different from that of other engines on exhibition. The steam-chests are at the ends of the cylinder, as indicated by Fig. 5, and the valves are circular gridiron or "damper" type, turning back and forth on flat seats; the steam is admitted at four ports which are covered and uncovered by corresponding arms of the valve. Another large engine-generator unit sets opposite the last-mentioned unit, on the other side of the central passage. This is a two-cylinder compound vertical engine of 1200 horse-power with cylinders 31½ ins. and 53 ins. in diameter, high and low pressure respectively, and 47¼ ins. stroke. It is direct-coupled to a 12-pole 500-volt generator, to run at 75 r.p.m. The generator has an internal stationary field; an external revolving armature is supported on the projecting shaft, which is provided with an outboard bearing, as shown by Fig. 6. At the other end of the shaft is a 30-ton flywheel; a steam starting engine is used to turn the wheel round by means of gear teeth on the inner face of the rim. When preferred, the company substitutes an electric motor for this duty. Seven of these engines are installed in a lighting station at Quai de Jemmappes in the eastern district of Paris, and the present machine is the eighth. The complete installation contemplates the addition of further units to a total of twenty-four, making a model station, with Belleville boilers on the upper floor. The Société Alsacienne, which manufactures these engines and generators, operates three factories at Grafenstaden, Mulhausen and Belfort; the machine illustrated was sent out from the Belfort shops.

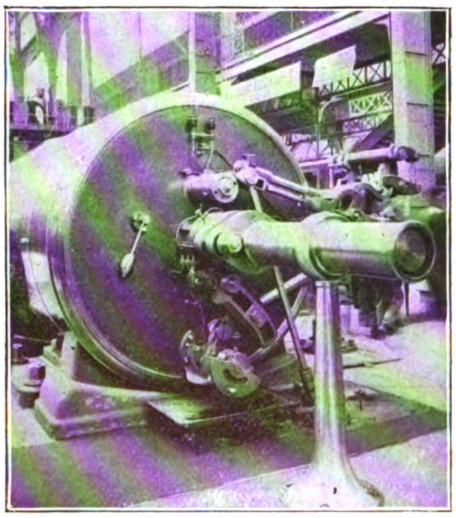

FIG. 5 —WEYHER & RICHEMOND VALVE GEAR.

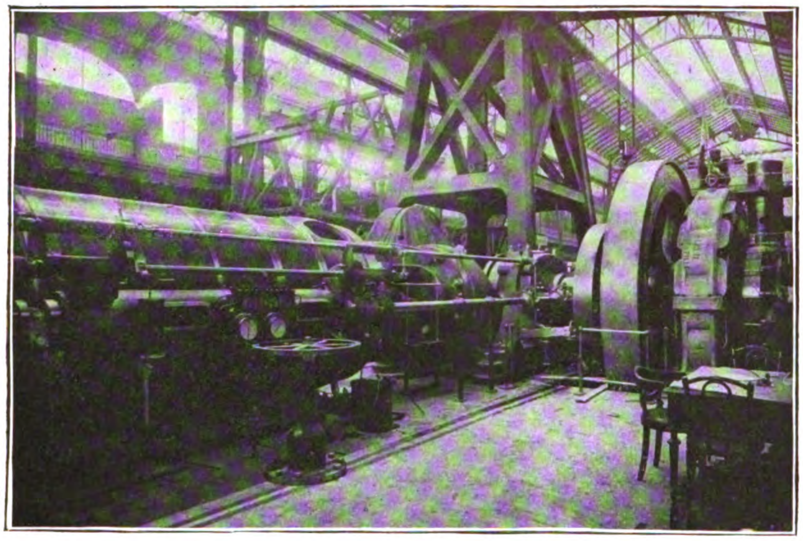

FIG 3 —SINGLE-CYLINDER 1000-H.P. WEYHER & RICHEMOND ENGINE DRIVING A CREIL DYNAMO.

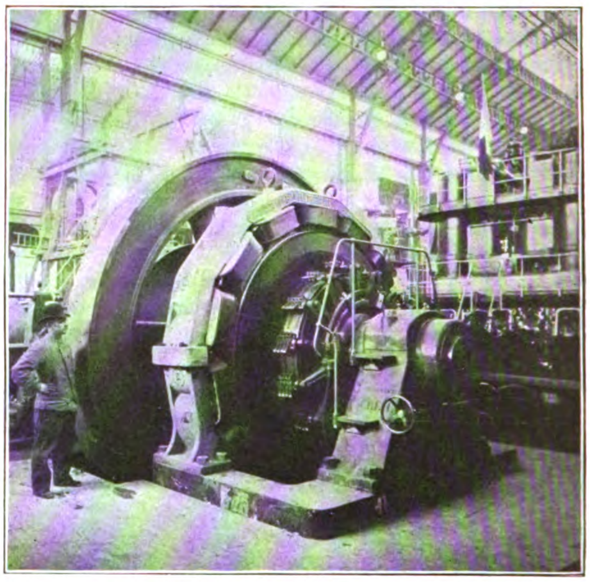

FIG 4.—ANOTHER VIEW OF THE CREIL DYNAMO IN FIG. 3.

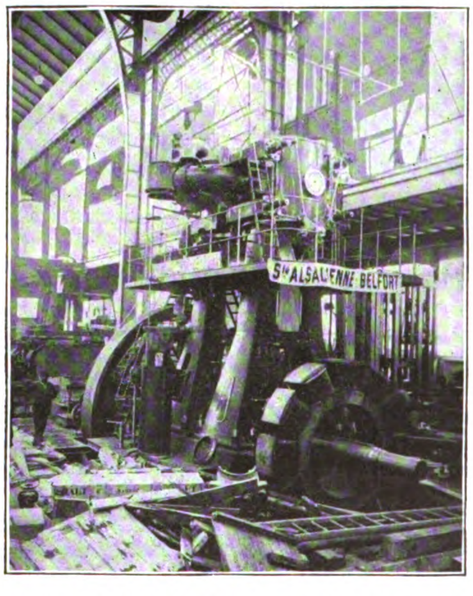

FIG 6. SOCIÉTÉ ALSACIENNE GENERATING UNIT WITH THE ARMATURE REMOVED.

Beyond the Belfort engine is another vertical compound two-cylinder engine, also of 1200 horse-power, but particularly of interest to Americans in that it is the only engine of American design in the entire power station. It was built by the Cail Company, a French concern, but from the designs of the E. P. Allis Company of Milwaukee. Between the two cranks is a flywheel alternator by the Postel-Vinay Company, which manufactures for the French Thomson-Houston Company. This machine is the only one in the French section giving as high an e.m.f. as 5000 volts, although in the German section of the foreign power house both Schuckert and Lahmeyer use this voltage in their alternators. The current from the Thomson-Houston machine is transmitted to the Esplanade des Invalides, where rotary converters transform it to direct current at 500 volts for lighting and small motors.

The Swiss section of the foreign power house contains some very interesting machines, all showing good design and careful workmanship, but they have not all been called into requisition by the administration. Escher Wyss & Co. show a horizontal tandem compound engine of 900 horse-power nominal, but capable of furnishing from 1200 to 1500 horse-power. This engine drives a three-phase Oerlikon alternator supplying current at 2200 volts to a portion of the Trocadero grounds for lighting the buildings of foreign colonies.

Sulzer Bros. of Winterthur exhibit three engines, each coupled to generators of different make. One of the most interesting machines is a small high-speed vertical tandem compound engine with two cranks at 180° and twin cylinders. This engine is in reality two compound engines working on the same shaft, but the valves are cross-connected by rods in such a manner as to be regulated by one governor. The alternator coupled to this engine was built by the Oerlikon Company, and supplies single-phase current at 2200 volts to transformers in kiosks on the Champ de Mars, whence current is distributed at 115 volts on the secondary circuits for arc lights illuminating the outer facades of the main Exposition buildings. Another engine by Sulzer Bros. is a tandem compound of 900 horse-power, driving an alternator built by Rieter of Winterthur. This machine is on exhibition only, and does not furnish current for use in the Exposition. The most noticeable feature is the external revolving field, with the poles projecting inwardly toward the stationary armature. The advantages claimed for this construction are that a good flywheel effect is obtained by having the field yoke at the furthest possible distance from the center, and the centrifugal strain is diminished by reason of the magnetic pull of the poles instead of being augmented, as in the case of revolving fields, with outwardly projecting poles.

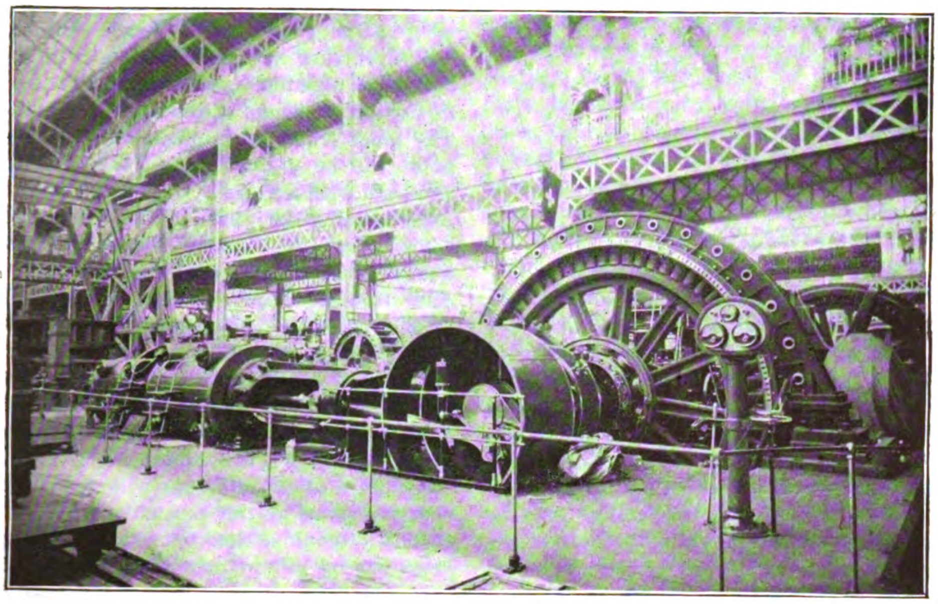

FIG. 7.—OERLIKON GENERATOR DRIVEN BY AN ESCHER-WYSS TANDEM COMPOUND ENGINE.

Another engine by Sulzer Bros. which is admirably built and appears to run perfectly is a 1700-h.p. triple-expansion four-cylinder horizontal engine, driving an alternator by Brown, Boveri & Co. at 83½ r.p.m. The cylinders are 23⅝ ins., 33½ ins. and 40⅜ ins. in diameter, high-pressure, intermediate, and two low-pressure cylinders, respectively, and the stroke is 59 ins. The exciter is driven by an 8 x 8 simple engine, with piston valve. Steam starting gear is used for turning the engine over. An improvement in this engine over others previously constructed lies in placing the high-pressure cylinder at the back, and the low-pressure in front, as in most American engines, instead of the other way. These engines, as are most of those exhibited, are equipped with jet condensers, and the regulations provide that the water from the condensers shall not have a temperature below 45° C. or 113° Fahr.

In the British section the engines of Galloway and Willans are being erected, and this portion of the foreign power house will soon be in condition to compare favorably with the exhibits of other nations. Two turbines are shown by C. A. Parsons & Co., using steam expansively; one of them has the condenser below the turbine shaft, so that the machine is entirely self-contained. This engine is used to run a small direct-current dynamo, the armature being mounted on the extension of the turbine shaft. A larger turbine, not intended for use in the Exposition, drives a four-pole alternator. In the French power house there are two de Laval turbines driving Breguet generators which furnish 700 amperes each at 250 volts; these supply a 250 + 250-volt three-wire system. All direct-current generators supply current to the Champ de Mars section only, the outlying portions of the grounds being served with alternating current of a voltage and frequency to suit the locality.

Two main switchboards are provided, from which the current from all the different generating units is distributed. These boards are on the ground level of the Electricity Building behind and on either side of the Chateau d'Eau, which forms the grand facade toward the Champ de Mars. The direct-current switchboard is divided into five principal sections; a group of ten panels on the left is devoted to the generators of the Suffren station; next are five feeder panels, then a voltmeter panel, five additional feeder panels, and seven generator panels for the Bourdonnais station. Bus-bars for the 250 + 250-volt three-wire system run the full length of the board, and the various machines are all connected in so as to constitute a nearly balanced system, the 500-volt dynamos being connected across the outer mains, and the 250-volt machines divided between the two sides. The alternating-current switchboard is divided into nine panels, corresponding to the different sections into which the Exposition grounds are divided; each panel is served by two or more machines of like characteristics, except in the case of the Fargot two-phase alternator, which is the only one furnishing this current and has a separate panel, supplying current to a transformer station on the western side of the Esplanade des Invalides. Rotary converters there furnish current at 500 volts for the motors of the moving stairways and other motors in the vicinity.

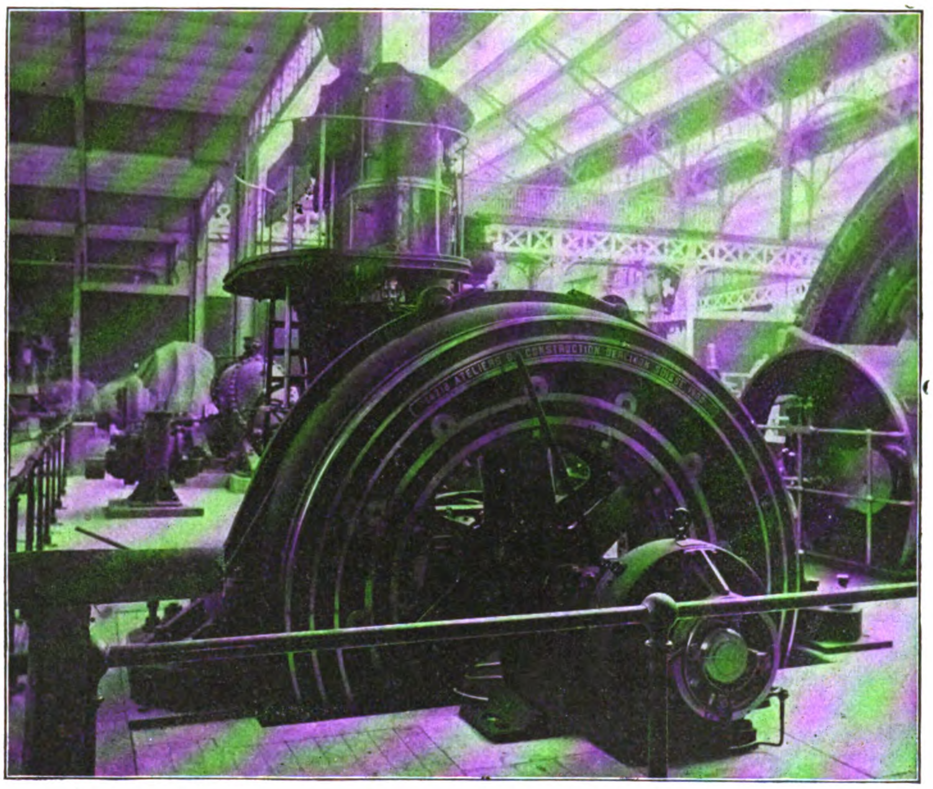

FIG. 8.—OERLIKON ALTERNATOR DRIVEN BY A SULZER VERTICAL COMPOUND ENGINE.

THE ARRANGEMENT OF STEAM PIPING IN CENTRAL STATIONS.—II.

BY WM. D. ENNIS, M. E.

A system of piping designed to illustrate what is considered first-class practice in modern plants is shown in diagram by Fig. 9. One 2000-h.p. engine and one 1000-h.p. engine, both cross-compounds, are assumed as the motive power. For these there will be provided, say, ten 200-h.p. water-tube boilers, set in two batteries. Each engine will have its own independent condensing apparatus. An automatic system for returning all of the high-pressure drips to the boilers must be installed. The feed water will probably pass through primary and auxiliary heaters and an economizer. The pressure carried will be 150 lbs. Water supply is assumed from a pond, well, or city water pipes under pressure. Mechanical stokers and mechanical draft will be used. For absolute security, the entire pipe system will be so arranged that no breakdown in any part can cripple more than half the boilers or more than one engine.

The boiler nozzles will each be 7-in.; the cylinder inlets on the large engine will be 10-in. and 14-in.; the outlets, 14-in. and 24-in. On the small engine, the inlets will be 7-in. and 10-in., the outlets 10-in. and 16-in. It is expected that five of the boilers will always be kept under steam, and that with forced draft two of them will be able to operate the smaller engine.

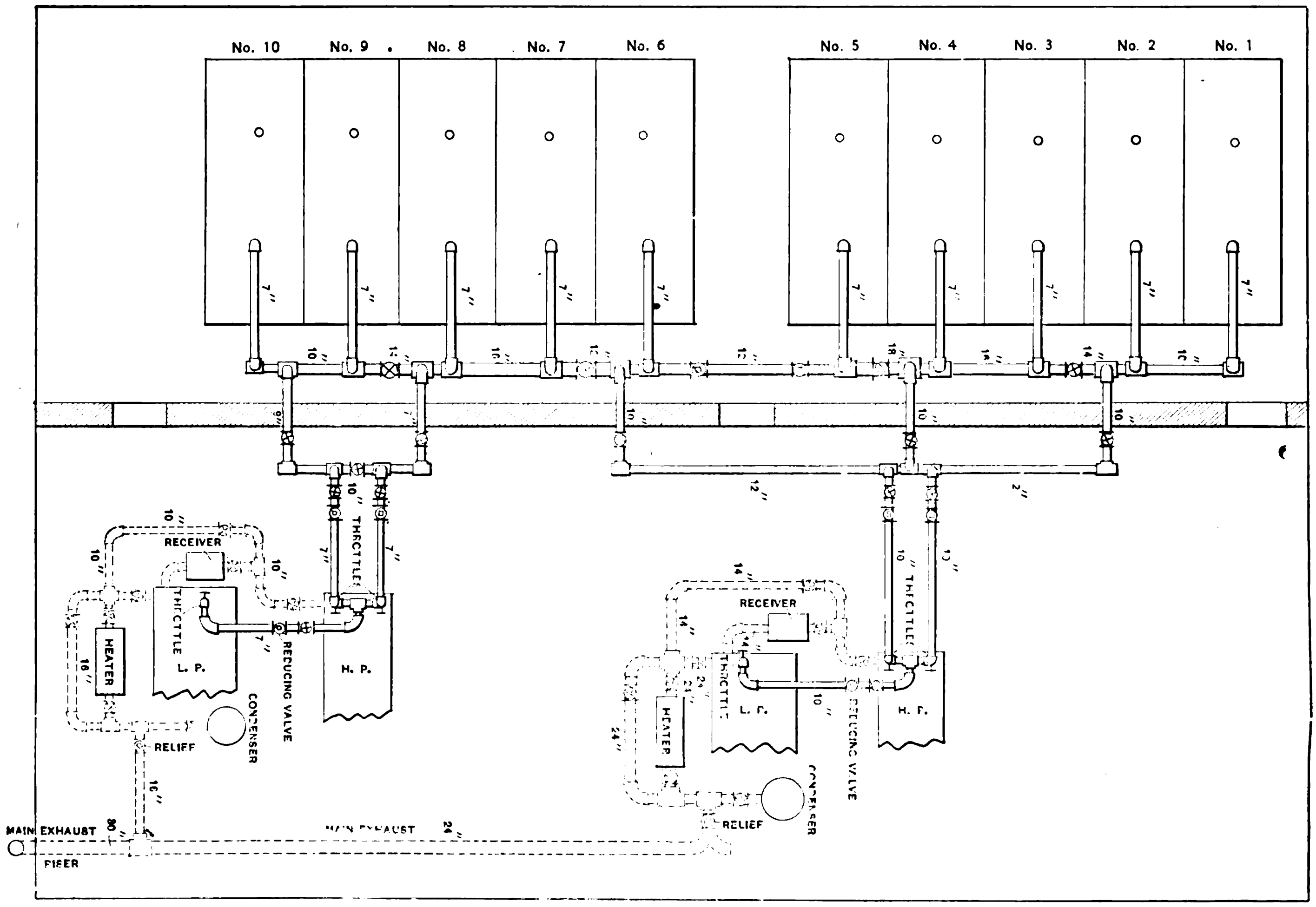

FIG. 9.—PIPING FOR A 3000-H.P. CENTRAL STATION WITH TEN BOILERS AND TWO ENGINES

The boilers being high, and the necessity of having valves in accessible positions paramount, the best location for the header will be near the floor, and consequently between the boilers and the dividing wall. Connections from the nozzles to the header will be pipe bends, which will bolt to Ts on the header and to angle valves placed directly on the nozzles. The expansion of so long a header being too great to be entirely taken care of by the swing of the bend and angle-valve flanges against the Ts and nozzle flanges, provision will be made for relieving it by placing a U-bend in the header, midway between the two batteries.

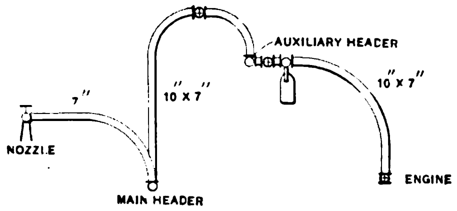

FIG. 10.—ELEVATION OF INDIVIDUAL CONNECTIONS.

In order that any two boilers may be placed in operation while all the rest are shut off, a valve must be placed on the header between each two boiler connections. No part of the header should be of less diameter than the main pipe to the large engine, which is 10 ins. The largest part should be of double the capacity of the two engine mains, or 18 ins. It would be objectionable to have so much weight in the U-bend, and this will probably be limited to 12 ins. The sizes of pipe and arrangement of valves on the header and boiler mains will then be fixed as shown in Fig. 9.

From these must be made suitable pipe connections for the two engines. The outlets will of course be from the top of the header, and in order that any two boilers may be used, will be run from each pair as cut off by the header valves. The first three pairs of boilers will be connected together by an auxiliary header in the engine room, of the size indicated. The pipes from the main header to this point will be 10-in., made of long bends, and each with a valve at its highest point. A second auxiliary header will be run as shown for the smaller engine. Both headers should be as high as it is practicable to place them.

Each engine is provided with duplicate supply pipes, each pipe having its own valves and separators. These pipes are sweep bends. One engine is fed from one auxiliary header and the other engine takes steam from the other header.

A glance at the diagram will show the security given by the expensive work installed. Should either battery of boilers be thrown out of service, at least 2000 horse-power could be obtained from the engine connected to the other battery. An accident on one of the 7-in. boiler mains would cripple only one pair of boilers; a break in the header would be no more serious. Any one of the connections between the main and auxiliary headers could be taken down and leave the plant capable of carrying the full load. A break in an auxiliary header would have the same effect; that is, the entire plant would continue to be operative at full load.

The engine pipes are in duplicate, and by gearing their controlling valves to operate from the engine room floor, a burst seam or joint could be shut off and the other pipe opened in a very short time. Plants piped in this way are rarely met with, but it is becoming more frequent to provide in some such manner as that indicated against all possible chances of a crippling accident.

In order to admit live steam to the low-pressure cylinders of the engines, if necessary, a connection from the main steam pipe through a reducing valve is shown. These may be made of pipe and fittings of the same size as the respective engine steam pipes.

The exhaust pipe system is shown by dotted lines. The high-pressure cylinders exhaust through receivers into the low-pressure cylinders, or direct to the condensers. The full exhausts go through or around the heaters to the condensers, a relief valve connecting them with the main exhaust, which will be of sheet pipe.

All the low-pressure pipes below 16 ins. in size will be of wrought iron with screwed flanges. Above this size, riveted plates will be made up with riveted flanges. On the high-pressure system, the common extra strong pipe with extra heavy flanges can be used up to 12-in., and heavy pipe and heavy riveted flanges for the larger sizes. The joints must be made with great care; probably no ordinary weight of flange will answer.

The condenser pipes will be arranged similarly to those mentioned for the 500-h.p. plant, and it will be best to have a separate injection pipe from the pond to each condenser, each pipe being provided with a strainer and by-pass.

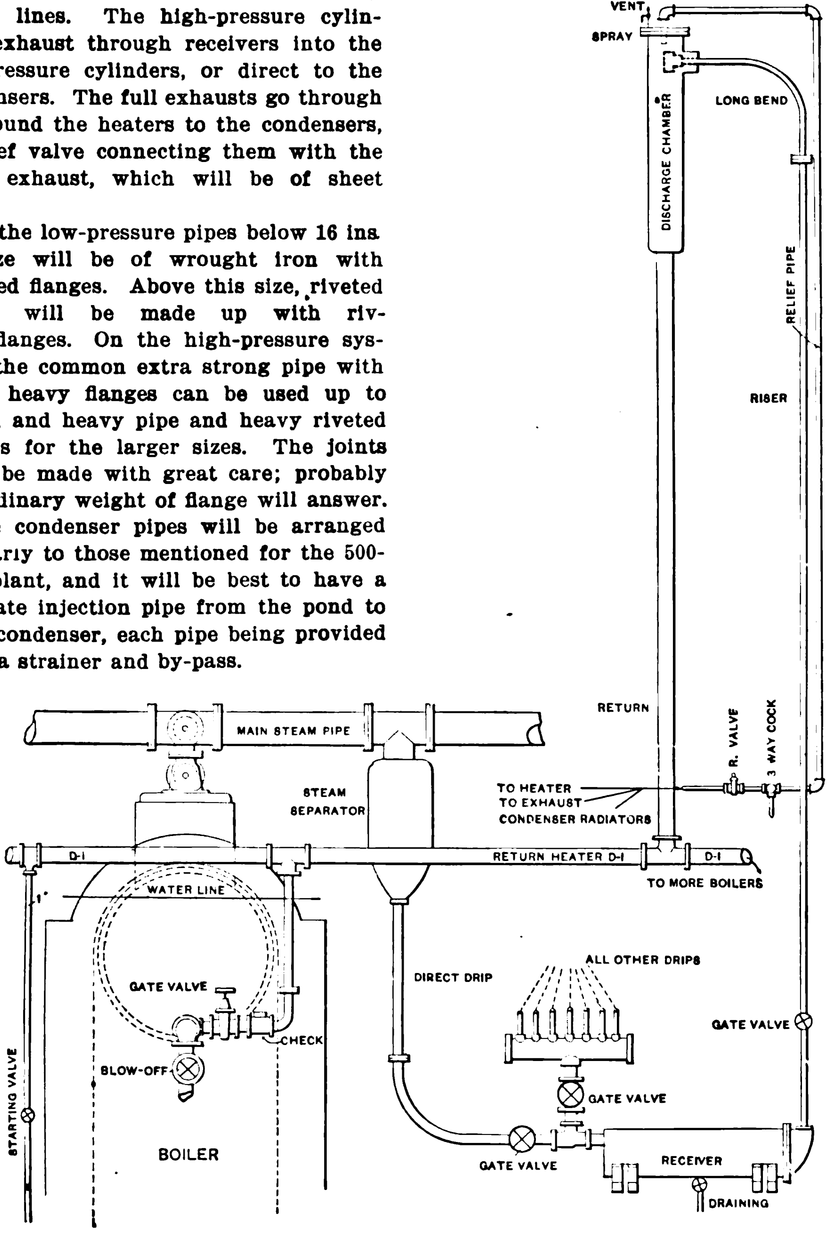

FIG. 11.—AUTOMATIC GRAVITY RETURN DRIP SYSTEM.

An auxiliary header for steam supply to the feed pumps, damper regulator, condensers, etc., may be run from tees on the forward boiler nozzles, and a duplicate set of steam pipes for this purpose may be taken from the drip mains which will be placed under the main and auxiliary headers.

Suction pipes from the three sources of supply to the feed pumps may be of cast iron, and each must be valved. The two or more feed pumps may be connected into a common main, and also independently to two boiler mains from which duplicate connections will be made to each boiler. The common main will probably be of wrought iron to the first (main) heater. From this point to the second main heater it may be of cast iron or brass, and so also to the supplementary heater into which all small exhausts will be piped, and to the boiler mains. These exhausts after passing through the heater will run to the engine exhaust main.

The main and auxiliary headers should be dripped at the bottom of every outlet tee. The drips from the latter header will be high enough to be returned direct to the boiler, as already explained. Those from the former may go to a pump and receiver, and be returned thence through brass pipe to the main boiler feed, or to an automatic return drip system, as illustrated in Fig. 11, the return from which is usually connected through check valves to the boiler blow-off pipe inside the blow-off valve.

The blow-off will not differ essentially in arrangement from those already discussed, but the large main would be preferably of extra heavy flanged cast-iron pipe to the building wall and of bell end cast iron beyond.

When a steam plant of this size is to be fitted up, piping becomes a science of the greatest complexity. The above suggestions are merely intended to indicate in a general way some of the principal problems met with and the steps usually taken for their solution.

There are certain features with regard to the systems of piping adopted in first-class plants that deserve mention. One of these is the "ring drum," examples of which are shown in Fig. 12. This illustration represents the main steam pipes in the power plant of a large government building now in course of construction, and the design was made by the mechanical staff of the United States Treasury Department. The system is evidently designed with a view to economy in head room, the floor space being comparatively ample. As will be noted, each of the eight water-tube boilers is connected from each nozzle with one of two 10-in. headers. The rear headers of the two batteries are carried around the end of the batteries and across the lines of fronts, to a 12-in. cross-header or drum. The headers in front of the boilers are similarly united with another 12-in. drum.

From each of these 12-in. drums an independent steam supply is carried toward the engines. Both cross drums furnish steam to 6-in. pipes which run to reducing-pressure valves. From these valves low-pressure steam for heating is run to an 8-in. low-pressure header. Two 5-in. pipes run from this header to a second 10-in. cross drum through auxiliary reducing-pressure valves, which diminish the pressure to a point at which the feed-water heater will stand it. The main engine exhaust, 10 ins. in size, runs through gate valves, either direct to the 10-in. heating drum, or through a feed-water heater by two ports to this low-pressure drum. If the engines should not be running, the feed-water heater can be supplied with live steam, which, after passing through the heater, is carried into the main engine exhaust, the direction of motion being opposite to that indicated by the arrows and just described.

Where could such a piping system as this be crippled so as to affect the working of the plant? It is difficult to fix upon any weak point. The only improvement which appears possible under the conditions would be to place the boiler main valves against the header tees rather than so close to the nozzles. The ring drums (which are not quite typical of their class, however,) permit of easy expansion in every direction; and at the same time the construction is structurally strong and apparently easy to brace against vibration. The main headers are too low for a simple gravity return of the drips, but this could hardly have been avoided. Steam for heating is properly taken from a comparatively low point, and the arrangement is such that any one section of piping in the plant might be removed without throwing a single boiler out of commission. It can readily be conceived that such a system would be expensive to install, but if the expense attendant upon a single day's shut down of the plant in a building of this kind is considered, it seems fair to charge a good share of the high first cost to service insurance, and that of the most reliable kind.

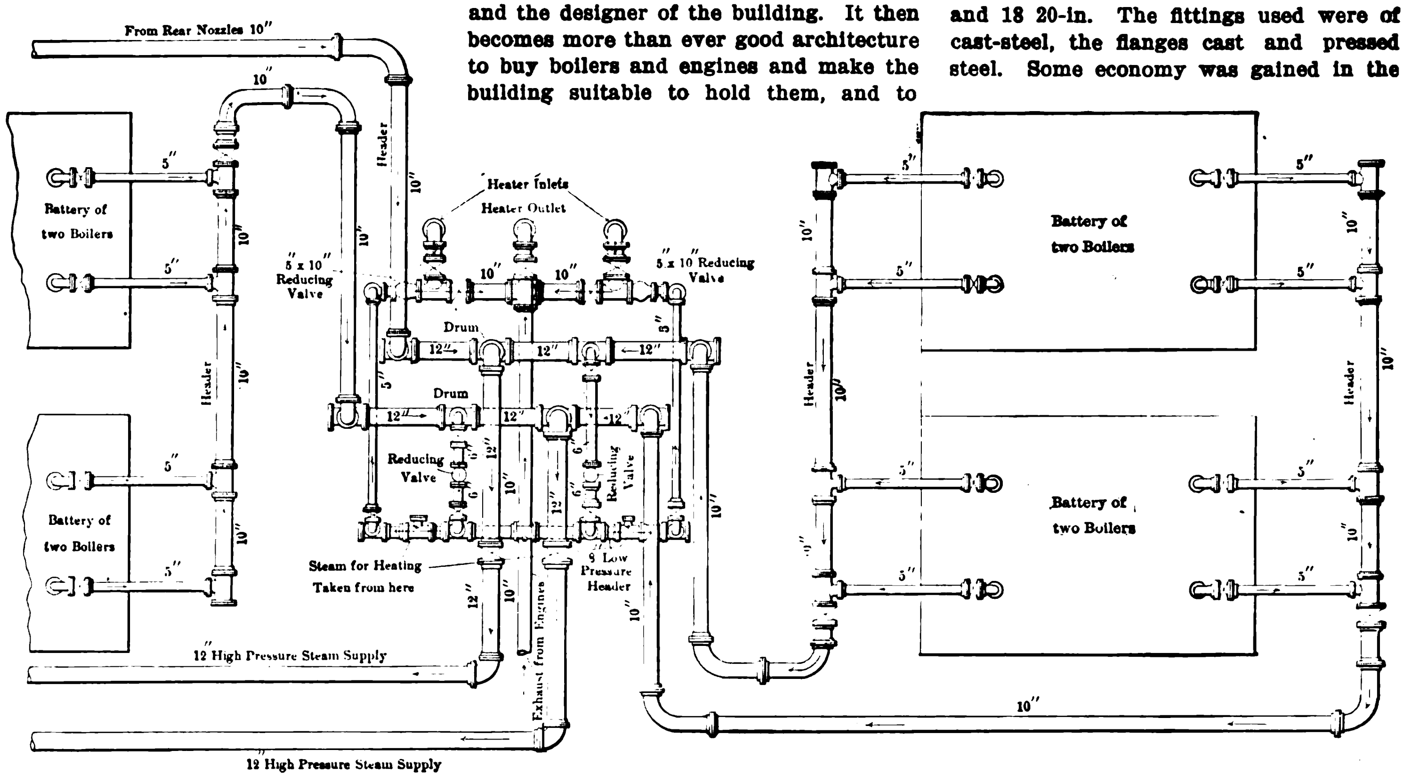
From Rear Nozzles 10"
10"
Header
Battery of two Boilers
Battery of two Boilers
5"
10"
5 x 10" Reducing Valve
Heater Inlets
Heater Outlet
5 x 10 Reducing Valve
Drum
Drum
12"
Reducing Valve
6"
Steam for Heating Taken from here
9 Low Pressure Header
12 High Pressure Steam Supply
Exhaust from Engines
12 High Pressure Steam Supply
Battery of two Boilers
Battery of two Boilers

FIG. 12.—MAIN PIPING FOR EIGHT WATER-TUBE BOILERS.

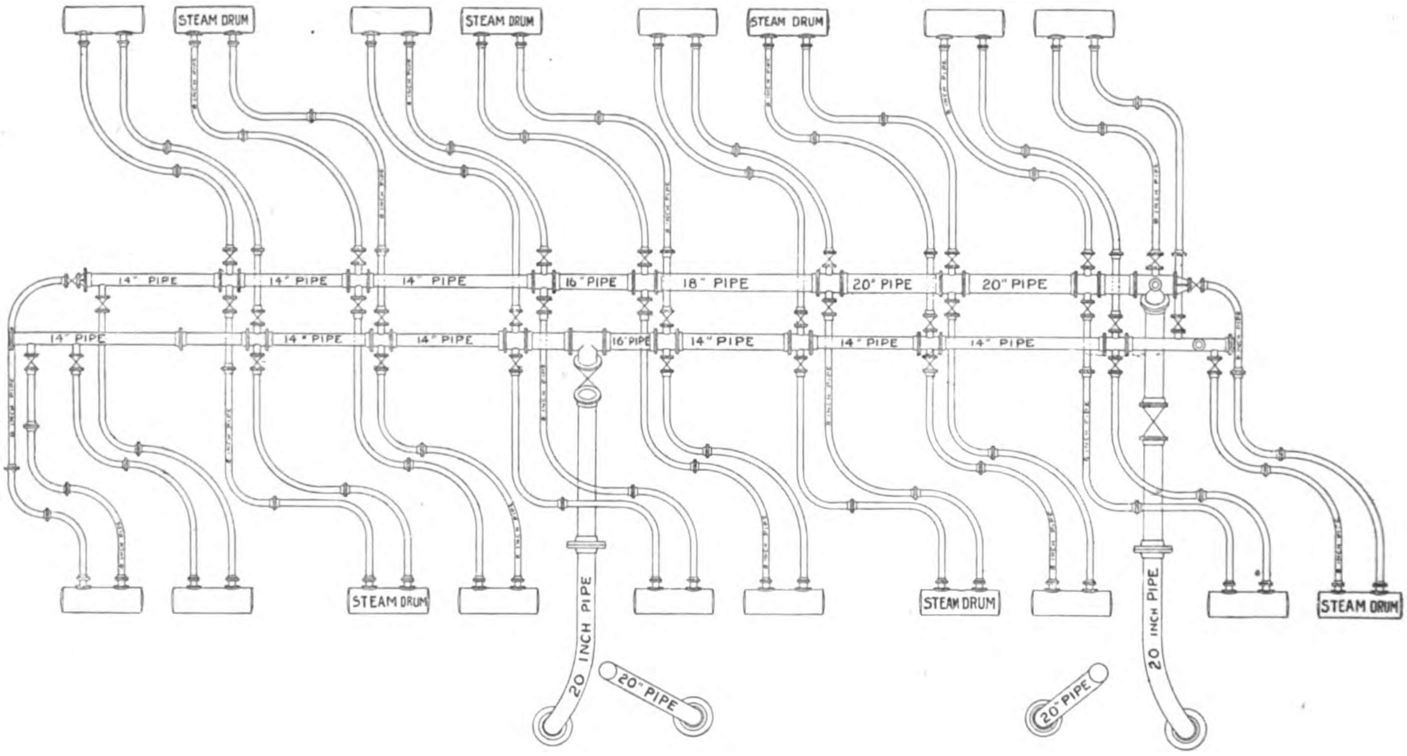
STEAM DRUM
STEAM DRUM
STEAM DRUM
14" PIPE
14" PIPE
14" PIPE
16" PIPE
18" PIPE
20" PIPE
20" PIPE
14" PIPE
14" PIPE
14" PIPE
16" PIPE
14" PIPE
14" PIPE
14" PIPE
STEAM DRUM
STEAM DRUM
STEAM DRUM
20 INCH PIPE
20" PIPE
20" PIPE
20 INCH PIPE

FIG. 13.—MAIN PIPING PLAN FOR AN 18,000-H.P. STEAM PLANT.

Where boilers are contained on more than one floor of a building, the arrangement of piping becomes a highly scientific problem, as well as a fertile source of trouble between the mechanical engineer and the designer of the building. It then becomes more than ever good architecture to buy boilers and engines and make the building suitable to hold them, and to build the piping system and set the engines and boilers to match it. Fortunately piping design is a most reasonable science in its demands, and the arrangement found best for piping will be found usually to correspond fairly well with a proper arrangement of the machinery.

Fig. 13 represents the piping system of a power plant containing a total boiler horse-power of 18,000, in 72 units, installed on three floors. The illustration shows the lower floor only, the second floor being an exact duplicate, and the third floor similar. There were used in the live-steam system alone 168 8-in. pipe bends, 12 10-in., and 18 20-in. The fittings used were of cast-steel, the flanges cast and pressed steel. Some economy was gained in the sizes of the pipes by adopting what was at the time (1893) a very high pressure, and it is worthy of mention that the largest steam pipe is 20 ins. in diameter. The arrangement is that of duplicate center headers with 20-in. vertical headers uniting the various floors as ring drums. Each boiler is connected with each header, and each header has its own vertical ring drum.

An accident on one of the ring drums might necessitate opening one valve and closing another on each of the 72 boilers, which would require considerable time. For this reason it seems as if an improvement would have been to connect each horizontal header with both vertical headers. An easier remedy would be to keep both valves always open and both headers under steam. This would be poor economy, however, on account of the condensation, and would be impracticable when making repairs to one of the horizontal headers. Another noteworthy feature is the comparatively great distance between the boilers and the mains. This, of course, means excessive condensation, which is largely compensated by the easy radius of the bends. The two 20-in. valves are rather awkwardly located, on sloping pipes, and it is difficult to see how they could be properly dripped. The turns from the cross headers to the ring drums might well have been made of larger radius; if necessary, the right-hand ring drum could have been supplied by a 20-in. long bend at the end of the straight header, and the left-hand by a special long-radius double-branch elbow. The fittings all appear to be of rather scant radius for strength and economy of pressure in transmission. The whole installation was at its time bold and original in conception, and is interesting as suggesting many features of design that have since been widely adopted.

It is interesting to compare the foregoing installation with that of the Metropolitan Traction Company's 96th Street power house, New York.* As in the preceding case, the boilers occupy three floors; ring mains are used in the boiler rooms and there are no duplicate headers or supply pipes. The absence of duplicate piping is a striking proof of the progress that has been made in this line of construction. The boiler mains are offset on a horizontal plane, a practice which admits of bracing the header so as to be absolutely rigid in all transverse directions, the offset bends having sufficient spring to take care of their own expansion. There is too little head room to permit of a long bend in a vertical plane from the boiler nozzle, and the connection of the main to the boiler drum is therefore made with an elbow. The mains are valved at their junction with the header.

In this arrangement the boiler mains grade toward the ring mains; these slope toward the outlet mains, and these in turn to the vertical mains. From the vertical mains to the engine separators is another constant descent. The slope is therefore always in the direction of the current of steam and toward the separators. Almost perfect drainage should be secured. There is not a pocket for water in the whole steam system.

It is interesting to compare the maximum size of steam pipe in this plant (16 ins.) with that in the plant partly shown by Fig. 13, which is 20 ins. The Metropolitan station has an aggregate boiler capacity of 21,750 rated horse-power; the other one 18,000 horse-power, a difference of about 19 per cent. The areas of the largest steam pipes differ by 56 per cent. These figures show conclusively the reduction in size of pipe attained by the use of high-pressure steam and economical engines. The day of very large pipes has passed.

The main exhaust from high to low-pressure cylinders passes through a receiver 60 ins. in diameter and 32 ft. long, which is supplied with live-steam coils for reheating. After passing through the low-pressure cylinder these pipes run to the respective primary heaters, and thence to the free exhaust. A valved by-pass is arranged so that the heaters may be cut out, and a relief valve is placed on the free exhaust so that a vent is assured if the condensing pumps which circulate water through the heater fail to work.

Theoretically, all the heat of the steam not actually turned into motion by the engines is returned to the boilers. The whole operation is a cycle, the path of which may be represented diagrammatically as in Fig. 14. On the left of the vertical dotted line the heat vehicle is steam, on the right it is water. Actually, this cycle is not realized because of losses in uncollected drips and leakage, and through condensation in the pipes and cylinders. As only the live-steam piping is covered, the loss due to cooling will be large on the exhaust and water pipes. If economizers had been used, the above cycle could have been started with coal instead of water. As it is, there is a loss in the flue gases to be added to those by drips, leakage, condensation and cooling. While the plant of the Metropolitan Traction Company does not, as a steam-generating station, represent the highest refinement of modern practice in every respect,* the arrangement of piping is a feature that cannot be criticised. This is modern and sound engineering, and the whole pipe system displays the best principles of design that are recognized. It is the largest, the most complete, and the simplest in existence, and may well be looked upon as a model for future designers.

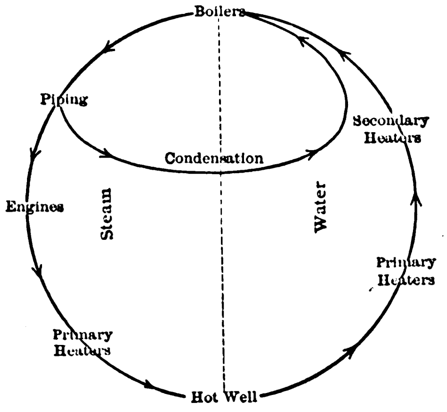

FIG. 14.—HEAT CYCLE.

THE CHOICE OF ARC LAMPS.

BY PROF. WILBUR M. STINE.

The cost of arc lighting is a topic of such perennial interest that papers discussing its various details are frequently published and rarely fail to elicit lengthy and interested discussion. This may be taken as an indication that the cost of the maintenance of an arc lamp is by no means an item that can be readily and clearly determined, and that it varies greatly according to local conditions. In fact, it may be said that the item of the cost of the maintenance of an arc lamp involves the entire installation, plant and distribution system as well, and the economy of operation. But, singuarly enough, in nearly every case, the discussion begins at the plant cost or the coal consumed, and the lamps themselves receive no attention other than to state their number; and this number is taken as the basis for the division of the total cost of installation or operation, to obtain a unit cost for the purpose of comparison.

While all these matters are of great importance and must be considered, yet such discussions are incomplete and begin at the wrong end. If the cost of arc lighting is to be seriously considered as an engineering study, it must either begin with the consideration of the appropriate arc lamp to use, or finally include this as the most important item in the entire discussion.

The case is very similar to the development of a water power. Suppose in its development costly retaining walls are built and a lengthy and expensive pipe line is laid; and that, further, considerable expense has been incurred in making a tail-race and in building a power house with its accessories. We will also suppose that the improvements so far have been in the hands of competent engineers, and that the hydraulic and structural features are all properly designed and installed. At this juncture the trained engineer is dismissed and the selection of the water wheel is made by the parties financially interested on the information furnished by catalogue literature and representations made by agents promoting the sale of their particular wheels. It is scarcely imaginable that anyone should be guilty of this breach of judgment; for, it is apparent, that the water wheel is the means for transforming the hydraulic power into mechanical power; and everyone would understand that it is a most essential matter to obtain on the power shaft as large a portion of the horse-power available at the nozzle as possible; and that the choice of the water wheel must be made on the basis of adaptability and efficiency.

This imaginary case of the hydraulic plant is by no means an exaggerated illustration of the arc lighting plant. The arc lamp itself has the same function to perform in the arc lighting installation that the water wheel takes in the hydraulic one. While the hydraulic plant is installed to develop power, the arc lighting plant is installed to transform energy into light. The product to be sold in arc lighting is illumination, and it cannot be too insistently emphasized that the function of the arc lamp is the transformation of electrical energy into illumination. Fundamentally, an arc lighting plant differs in no respect from a power plant, except in the final transforming device; in one case this may be a motor, while in the other one it is the arc lamp.

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* See American Electrician for March, 1900.

*By this I mean such refinements as economizers, draught fans and triple-expansion engines. Probably the plant is the most modern—for the particular conditions of the case. No doubt all of these things were figured down to a dollar-and-cents basis and the decision made in accordance therewith.

The choice of the arc lamp, then, must be guided by two considerations—adaptability and efficiency. It is a matter of common experience with those persons who deal with arc and incandescent lighting as engineering subjects, that there exists not only marked indifference toward the lamp itself in either case, but an inexcusable amount of ignorance of the nature and operation of lamps regarding both their efficiency and adaptability.

The proper discussion of the choice of the arc lamp must begin with a study of the most elementary properties of such lamps.

THE DIRECT CURRENT OPEN ARC.

This type at once divides itself into two classes, according as the lamp is designed for use on series lines, or in parallel on incandescent lighting and power circuits. These classes differ structurally in their starting and regulating mechanism; but in the operation of the arc itself they are practically alike, the variations between them being due to smaller changes in the intensity of the current in series working.

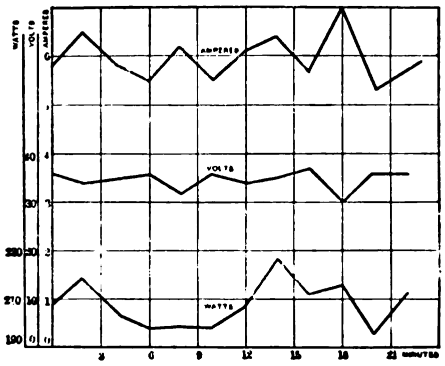

FIG. 1.

What may be termed the "characteristics" of an open arc with continuous current are exhibited in Fig. 1, for a lamp operated on an incandescent lighting circuit of 110 volts. The lamp was in excellent adjustment and may be considered as a typical one of its kind. It is noticeable that the intensity of the current changed rapidly and through wide values in step with rapid changes in the voltage which was taken between the carbon tips. For all changes indicated by the curve of watts, the candle-power may be considered as varying directly with the changes in the watts. It is evident that rapid and marked changes in the illuminating power of the lamp occurred during the test, which was not begun until the lamp had attained a normal condition of burning. The arc was a short one, the volts ranging between the values of 30 and 37. For the sake of comparison, the characteristics for a lamp of the series type operated on a commercial arc lighting circuit of 6.8 amperes, are shown in Fig. 2; the lamp in this case being also an excellent representative of its class.

The efficiency of open arcs with continuous current ranges between 7 and 10 per cent. In obtaining this, only the watts expended in the arc itself are considered, the potential difference being taken between the carbon tips. From this there should be deducted the watts lost in the coils of the lamp and in the resistance when used on constant-potential circuits. In the case of the lamp whose curves are shown in Fig. 1, the mean hemispherical efficiency is slightly greater than that of an equivalent number (about twelve) of incandescent lamps, the efficiency of the incandescent lamp being taken at five per cent.

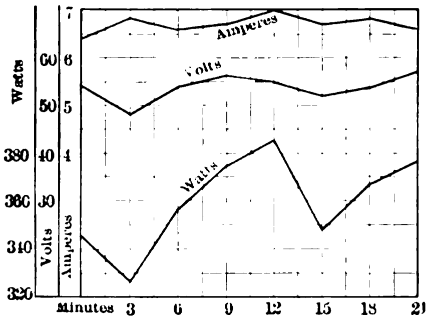

FIG. 2.

The space distribution of the illuminating power of the open arc is indicated in Fig. 3, and diagrammatically in Fig. 4. Such curves are so well known that they need no comment, except to note that the maximum candle-power shown in Fig. 3 occurs at an angle of 40 degs. below the horizontal.

There is yet a lack of sufficient attention being paid to certain causes which influence the distribution of the illuminating power. These are confined very largely to the positive carbon, which is the source of more than 80 per cent. of the entire illumination. The positive carbon should be somewhat soft, even at the expense of shortened life, and be as pure as possible and of uniform texture, so that the crater may shape up well and hold the arc in one spot for a length of time. It must be remembered that hard carbon emits bluish light and lessens the illuminating power; cheap carbons, and made hard that they may have long life in burning, yield very low economy, as they reduce the efficiency of the arc out of all proportion to the saving they effect.

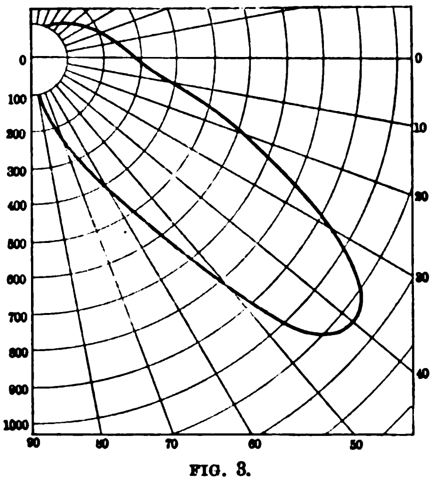

FIG. 3.

The mean hemispherical intensity, illustrated in Fig. 4, probably yet needs some explanation for the general reader. In this case the mean hemispherical intensity, or candle-power, was found by integrating the area of the two bat-wing curves with a planimeter. This area was taken as that of an equivalent semicircle corresponding to a radial intensity of 580 candle-power. If all the illumination given out by the arc below the horizontal plane through the center of the arc was uniformly distributed, or given out hemispherically, the candle-power in all radial directions would be equal and be 580 candles in intensity.

THE ALTERNATING CURRENT ARC.

This type is readily understood if it is regarded as fully described by the term "alternating"; or more definitely, the alternating current arc is the result of a series of pulsating continuous-current arcs, whose polarity is continually changed. In this manner the characteristic positive crater is formed now on one carbon tip and again on the other one.

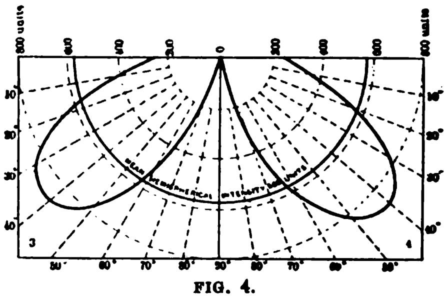

FIG. 4.

For any one condition of the polarity the distribution of the illuminating power is chiefly either above or below the horizontal plane through the center of the arc, dependent upon the positive crater being located on the lower or upper carbon tip, the distribution being very similar to that shown in Fig. 4. Suppose that the intensity of the light shown by this curve decreases until it is practically null, and then increases again to its full value, but located now above the horizontal plane; and further consider this process to be repeated 60 or more times in the second: and an almost complete representation will be formed of the changes in the intensity and distribution of the light from an alternating-current arc. The alternations being so rapid, the effect on the eye is one of continuous illumination, and only in the sense of such an abiding sensation are the curves in Fig. 5 a correct representation of the distribution of illumination from this type of the arc.

Owing to the rapid alternations of polarity, the positive carbon does not form a crater so intensely heated as it does with a continuous current and with the same energy expended—there is not time enough for it to occur; and the negative carbon tip is always hotter than it would be with a constant polarity—there is not time enough for it to cool off. These temperature effects change the candle-power proportionally; the resulting temperature of incandescence is always lower than in a constant-polarity arc, and the candle-power emitted for each watt expended is correspondingly decreased. For a given amount of energy absorbed in the arc, an arc supplied with an alternating current will emit a much lower candle-power than a constant-polarity one. The efficiency, then, of the alternating-current arc is low; it ranges between 30 and 70 per cent of the efficiency of the constant-polarity arc.

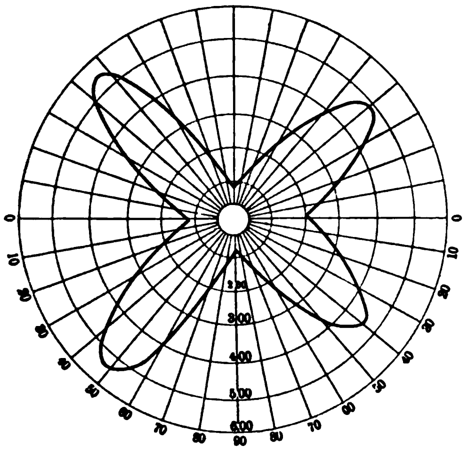

FIG. 5.

The especially notable detail in the light distribution is that it is practically as great above the horizontal plane as it is beneath it. This may be an advantage in some cases, while in others it is a positive disadvantage.

THE ENCLOSED ARC.

Enclosed arcs may be operated either by an alternating or a direct current, and while the enclosure of the arc in a small envelope produces a marked change, it does not alter the essential characteristics in kind. Compared with the open arc, its enclosure makes it possible to operate it at a higher potential difference with increased length of arc; the light distribution is somewhat flattened, so that the radial distribution of the light is improved. The curve of the distribution of the light from such an arc is exhibited in Fig. 6, and it is seen that the maximum intensity occurs between 30 degs. and 40 degs., while the distribution at all other angles is improved. Comparing this curve with that in Fig. 3, the maximum direction has been slightly raised toward the horizontal; this is a decided gain, for it means better illumination at a greater distance from the lamp. The intensity, too, between 40 degs. and 75 degs. is very satisfactory, and outside of the shadows of the negative carbon and the lamp frame the illumination would be fairly uniform. This is a decided advantage over the open arc, which, in contrast, illuminates a ring about it brightly, while within this ring the illumination rapidly falls off. So far as the light distribution is concerned, the enclosed arc is better adapted for both street illumination and that of large rooms than the open arc. The efficiency of the enclosed arc under the best conditions of operation and with a clean envelope may be as high as 8 per cent.

When the arc is enclosed in a small envelope, it is possible to operate it at a much higher potential difference than when open. The envelope reduces the rate of cooling of the arc both by radiation and by drafts; and thus protected, a long arc is as steady and reliable as a short one. The practice with the enclosed arc commonly falls within the limits of 50 to 90 volts. It is this peculiar feature of the arc which makes it flexible in adaptation to incandescent lighting and power circuits. The gravest defect of the enclosed arc is the influence of the envelope in lowering the mean spherical candle-power and the efficiency; though in this connection it must be repeated that the better light distribution from the enclosed arc makes it a more efficient lamp for illumination in certain specified directions. It will not answer to discuss the open and enclosed arcs simply as types and compare their efficiencies; they can be justly and intelligently compared only when the conditions of service and illumination are also considered and are given their due share of importance.

The efficiency of the enclosed arc is very largely a function of the character and condition of the envelope; when this is allowed to become thickly coated internally with fumes and carbon, the light becomes decidedly yellow in quality and is very greatly reduced in intensity. Aside from this detail of cleanliness, the highest efficiency follows the use of a clear glass envelope, and the efficiency is materially reduced by the use of opal or ground glass globes or envelopes. This will presently be discussed at length.

Another excellence of the enclosed arc is the increased life of the carbons; these last from 10 to 15 times as long as in the open arc, with a consequent saving not only in the cost of the carbons, but in the attendance. The enclosure of the arc, too, has resulted in simplifying the mechanism of the lamp and reducing its cost. There are a number of commercial lamps to be obtained which show an almost ideal simplicity in their design, and this decreases the repairs, and increases the probability of satisfactory operation.

It is a singular historical fact that the earliest arc was an enclosed one, as Davy experimented with this form as early probably as 1808.

The characteristics of the enclosed arc when the lamp is well designed are radically different from those shown in Figs. 1 and 2. The curves are practically straight lines slightly sloping toward the feeding point; and it is only at the instant of feeding that the curves rapidly change their slope. The interval between the feeding points is from 15 to 30 minutes, depending on the length of arc and the sensitiveness of the feeding mechanism. For general purposes it is the only form of arc to use with the alternating current, and under such circumstances it is not its least merit that the annoying hum of the alternating current arc is materially reduced by the use of an envelope.

THE ABSORPTION OF LIGHT BY GLOBES AND THE ACTION OF REFLECTORS.

This is another feature in the operation of arc lamps which generally does not receive sufficient attention. The carelessness and thoughtlessness with which both ground glass and opal reflectors are used is at times little less than shocking. The unavoidable and necessary waste of heat energy in the steam plant must be endured inasmuch as it is inevitable. But consider the pains and expense incurred to render the electrical generation efficient and the line transmission economical. Then this dearly-bought barely two per cent. of light energy is ruthlessly reduced one-quarter or one-half by needless absorption in a globe or envelope!

The real object in a globe or reflector is to modify the radial distribution of light, and by diffusion to render it more nearly uniform. The aim should be in such an operation to accomplish the diffusion with the least possible loss of spherical candle-power. No commercial device accomplishes this as well as could be desired; and where diffusion is not absolutely required nothing but clear glass of the best quality should be used. When diffusion is needed, the most efficient means should be selected. One of the best devices is a well-made holophane globe, which does not change the color of the light in transmission through it; a slightly opalescent globe also gives a fairly high efficiency. Williamson and Klinck have found the values given in the accompanying table:*

	Efficiency. Per cent.
I. Holophane globe, clear glass.........	87
II. Ground glass globes......................	79.3
III. Plain opal glass globe....................	68.5
IV. Slightly opalescent globe..............	90.2
V. Flat opal glass globe...................	86.8

Among these various globes, the holophane is best adapted for the diffusion of the light and is especially suitable for indoor illumination. The worst possible globe to use is the opal glass one, which simply reduces the intensity of the light without changing its distribution, and also makes it yellow in color. Rather than resort to the opal glass globe it is better to use an arc lamp of lower candle-power.

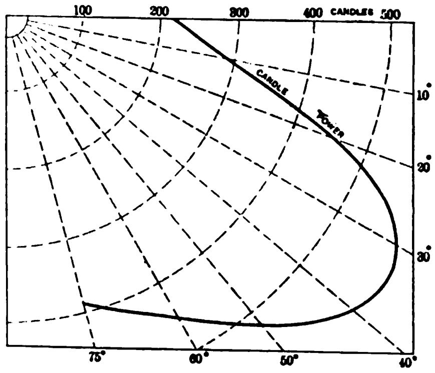

FIG. 6.

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* Williamson and Klinck. Jour. Franklin Institute; January, 1900.

Diffusion is only accomplished by the use of a reflector or a holophane globe; though the efficiency of most commercial reflectors is very low, and their use is only justifiable when a desired direction is to be given to the illumination.

The study of the several varieties of the arc is not alone sufficient to guide in the intelligent choice of the particular lamp to employ in any given case; this choice should be made after due allowance is granted to the conditions under which the lamp is to be used. When the condition of service is the lighting of streets, what in general may be expected of each variety of lamp? For comparison, lamps of equal mean hemispherical candle-power will be selected, representing the alternating-current and the continuous-current enclosed arcs, and the open arc. The open arc lamp was fitted with no device whatever for diffusing its illumination, while both the alternating and continuous current arcs were provided with enameled reflectors. The location of the arc is taken to be 25 feet above the street. For distances along the street from the foot of the perpendicular through the arc, the intensity of the illumination caused by the open arc is greatly in excess of either of the others; while at a distance of 50 feet the intensity of the illumination of the three is about equal. From this point the open arc falls below the values of the others; and at a distance of 125 feet the alternating-current arc shows the highest intensity, the continuous-current arc about three-fourths and the open arc about one-half of this value.

If the street is lined with tall buildings, the alternating-current arc, owing to its superior illuminating power above the horizontal plane, will light the upper portions of the buildings better than any other variety of lamp. For the ordinary street, however, this illumination is contributed to the clouds and proclaims the location of the town at a distance.

It must be remembered that the distribution of equal illuminating power from each type of the enclosed-arc lamp is better at all points along the street than from the open arc, unless for some reason a brilliant illumination near the base of the lamp is especially desirable. The foregoing statements are all based on the use of clear envelopes for the enclosed arcs.

An annoying feature of the open arc is its rapid change of position, so that any stated value for the intensity of the illumination at a particular point obtains for a very short time, and this illumination strengthens or weakens intermittently. The open arc as a class has received abuse from this fact. Unfortunately, this is the actual condition of affairs in the great number of arc lighting plants. The type of lamp is unjustly censured on this account, though its erratic behavior is largely owing to poor construction or faulty condition of the regulating mechanism, and more especially to the use of unsuitable carbons. Almost invariably unsuitable carbons are used, and it is questionable if the proper carbons are made in this country for open-arc lighting service. The manufacturing companies are not wholly to blame for this, since they are guided largely by the demands of the trade. It is insisted upon here that the open arc burning suitable carbons is reasonably and satisfactorily steady in its illuminating intensity at any particular point, unless the unavoidable flickering of the light is considered wholly objectionable.

In justice to the enclosed arc, it is in the line of progress to shield the arc against drafts and excessive loss of heat; but this shielding is always accomplished at a sacrifice, and the extent of the sacrifice is dependent on the foolish use of opal or ground glass envelopes when not strictly needed and the care with which the envelopes are watched that they shall be cleansed or replaced when soiled. The usually advanced argument in favor of the enclosed arc is that the increased length of life which it gives the carbons will lessen the attendance; but emphatically it lessens the illuminating qualities of the arc in about the like proportion—that is, the envelopes are cleaned or replaced only when the lamp is carboned. This is not sufficient, for one night's burning may foul the envelope so greatly that it should be cleaned. If adequate and efficient results are to be obtained from the enclosed arc, the attendance should be almost as frequent as that required for the open arc.

Suppose the fuel burned in the arc lighting plant is soft coal; the careful fireman will clean the boiler flues daily, for he knows that the deposit of carbon on them lessens the proportion of heat that will be transformed into steam. If the flues were allowed to go uncleaned for a week or longer, perhaps as much as one-half of the available heat would be lost. No one in charge of a steam plant would be so careless and thoughtless that he would allow the flues to become fouled. This, which is exaggerated in boiler practice, occurs in reality in many arc lighting plants in the lamps themselves, where the enclosed arc is used. The fouled envelope very greatly cuts down the illuminating power of the arc, and to the extent to which this is reduced it cuts down the exact equivalent proportion of the efficiency of the fuel burned. If the envelope is clean, an enclosed arc of a certain size should require five pounds of coal, say, for an hour of burning; when the envelope is very foul it may require seven or eight pounds to produce an equal illuminating power for the same length of time. With foul boiler flues more coal must be burned to maintain the service and the owner of the plant soon becomes painfully aware of the expense; with foul lamp envelopes, it is the public which is defrauded, and while the operating expenses are not increased by the condition of the envelope, the street illumination grows poorer and poorer, and the public becomes justly dissatisfied with incompetent service.

To return directly to the quantitative comparison of the three types of arc lamp, the statement made that they were taken of equal mean candle-power needs further explanation to avoid the conclusion that the best efficiency of the lamps is also equal. The open arc is the most efficient of the three; if this lamp absorbs, in this instance, 300 watts, there would be required under the best practical conditions about 375 watts for the maintenance of the enclosed continuous-current arc, and 400 to 450 watts for the alternating-current arc, without the use of reflectors. By the use of reflectors the arcs are made more nearly equal in efficiency for street lighting.

A misleading term of late has come into discussions of the comparison of arc lamps, namely, "watts per mean sperical candle-power." If all the conditions of burning were uniform and justly favorable, this term would not prove objectionable.

The type of the lamp may be of less moment than the quality of the carbons. So long as the regulating mechanism of any kind of arc lamp is adequate, the essential feature of the lamp is the arc itself. The effect of the enclosure of the arc as well as the character of the current has already been discussed. Now in turn, the intensity of illumination is not alone to be considered; all colors of light do not have an equal illuminating power, and this is decreased to the extent that the color departs from white, or yellowish white, and becomes bluish white. However the arc is maintained, and whether enclosed or not, the final efficiency of burning and the illuminating power as well, is more dependent on the quality of the carbons than any other detail, except perhaps, the cleanliness of the envelope.

Both the cost of installation and of operation are items that are determinate only when all the conditions of each case are known and properly rated. For the sake of comparison between the types of lamps under discussion, certain values obtained by Wait [*] will be quoted, and since they are based on the same conditions they are comparable, though in any one instance they are not to be taken as final.

Constant Current Service.

Watts.	Enclosed arcs.	Cost per lamp.	Cost per year.
400	Alternating current.....	$146.50	$52.86
450	Alternating current.....	155.24	57.85
300	Direct current...........	117.90	41.75
450	Direct current...........	147.00	56.07
	Open arc.		
450	Direct current...........	142.00	62.58

The Future Development of the Steam Engine. — In a paper of this title recently read by Mr. A. Saxon before the Manchester Association of Engineers, England, the prediction was made that steam pressures will be increased to at least 500 lbs. per sq. in. The author also stated that the increased steam pressure would naturally lead to increased engine speeds, but he omitted to make any suggestions as to how lubrication was to be effected under the enormous pressures predicted.

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[*] H. H. Wait, Trans. A. I. E. E., 1899, page 579.

OPERATING ECONOMIES IN CENTRAL STATION PRACTICE.*

BY W. L. ABBOTT.

In every central station there grows up a characteristic system of practices, good, bad or indifferent, due partially to peculiar environments and partially to the ability of the operating force. Through natural selection the best of these practices are gradually crystallized and become the unwritten code of rules for the direction of the internal affairs of the station. Some of these practices, while the very best for that station in which they originate, may prove very unsatisfactory when transplanted into other stations, yet it is largely due to the cordiality with which central-station managers impart to and adopt on trial from each other, new methods, that the present rapid improvements in operating details are being made. It is in the hope that some of the methods herein outlined may be new and feasible in other places that these suggestions are offered.

The saving and renovating of waste and oil is an ever-present and variously handled question in all stations. Some simply use the waste until it is oil-soaked and then burn it under the boilers; others go to the other extreme, and use wiping towels, which are carefully saved, washed and used over again. We favor a middle course, using a good quality of waste, first on the finer parts of the machinery and then for coarser work, after which it is put through a washer consisting of a train of rolls over which hot water is running. This extracts nearly all of the oil, and much of the dirt. The oil and water are caught in a receptacle, the oil separated and passed to the oil purifier, and the waste is put into the drier.

This is a sheet-iron box 30 ins. square and 6 ft. high, filled with shelves one above another made of wire netting and spaced about 10 ins. apart, for the reception of waste to be dried. The case stands a few inches from the floor, and in the bottom, which is open, is a steam coil. A door occupies one full side, and to the top is connected an 8-in. galvanized pipe leading to the boiler breeching for the purpose of obtaining a draft. The whole thing is quite simple and inexpensive, yet it will thoroughly dry a charge of 200 lbs. of damp waste in a few hours. This dry waste is somewhat harsh and knotty, but has better absorbing qualities than new waste, and we use and wash it over and over again. In practice the oilers are allowed but three-quarters of a pound of new waste on a shift, to keep a 1200-h.p. engine clean, but they are allowed all of the washed waste they want.

In separating oil from waste it is difficult to say which is the by-product and which the direct product, as from 100 lbs. of oily waste we get 40 lbs. each of oil and waste, and one product is about as valuable as the other.

The amount of engine-oil used at our Harrison Street station, I think, has been reduced to the lowest possible minimum, as it amounts to only about 50 gallons of new oil each month. This is obtained by catching and re-refining all the lubricating oil used on our machinery, which is quite readily possible on vertical engines. The drains from our crank-pits are carried down into the oil refiners, and the oil from the waste is all saved and put through a purifying process. I have spoken of oil-refiners, and of refining the oil, instead of filters and filtering the oil, for the reason that we have no filters and do no filtering, but purify the oil by settling and boiling.

Our filters consist essentially of three tanks, the first of which receives the oil from the engines mixed with cylinder drips, and water from the journals, etc. When this enters the first tank, which is, say, half full of water and half full of oil, the water and oil separate; the water going to the bottom, where it is drawn off through a trap, and the oil going to the top, to be drawn off through an overflow. From the first tank the oil flows to a second tank in which is a steam coil under a pressure of approximately 100 lbs. This heats the oil up to about 250 degs., at which temperature the water is driven off in the form of steam. Owing to the surface tension of the oil around the small globules of water which is held in suspension with it, the water will not vaporize at a lower temperature. This tank is of such a capacity that the oil is about two days in passing through it. From the second tank the oil goes into the third tank, where it is allowed to stand about the same length of time, and where any sediment it may contain will be deposited. From the third tank the oil overflows into a large storage tank, where it is kept until it is drawn off to be used.

The question of cylinder lubrication was once a very perplexing one for us, but after studying and experimenting, we settled the question in such a way that it has not beeen open for several years. We had great trouble with cylinder oil, and much difficulty in trying to find an oil which would lubricate all of the cylinders of our triple-expansion engines from one lubricator. We have not found such an oil and do not expect to. We could find an oil which would lubricate the high-pressure cylinder, and we could find an oil that would lubricate the low-pressure, but we could not find a combination which would lubricate all of the cylinders perfectly. We have, therefore, adopted an oil which will lubricate the high-pressure cylinder excellently, the intermediate moderately well, while the low-pressure shows only a slight trace of oil. As there is no cutting or scratching in the low-pressure while it runs dry, and as the high-pressure cylinder makes a prompt and vigorous protest if allowed to run dry for a few moments only, we have adopted the oil which will give the best results in the high and let the low be content with what it gets.

We use a heavily compounded high fire-test oil fed into the steam pipe near the throttle, and find that a gallon of oil so fed will give good lubrication for a 1200-h.p. engine for twelve hours. I have seen a compound engine of this capacity fed at the rate of nearly a gallon an hour without obtaining satisfactory lubrication; the whole trouble lying in the fact that the oil was not adapted to the particular conditions under which the engine was working, and I think this may account for the unmeasured praise or unstinted abuse which different brands of good oil receive from different engineers; and I think, furthermore, that the difference between a good oil and a poor oil made from high fire-test stock lies almost wholly in the amount and kind of compounding.

In arranging an operating force and the payroll of the central station the superintendent should carefully arrange his force so that he would at all times have men enough to take care of the amount of work on hand, and at no time have a surplus of help. Further than this, a considerable saving in money can be made by paying the operatives partially in hopes and promises. By this I mean to have a well-defined and well-known line of promotion, and let each one know his position in that line and know that his chances for promotion depend upon his ability, fidelity and length of time in service. The most demoralizing and disorganizing practice that can be introduced into a central station is to put a new man, the relative of some official, or the friend of some politician, into a desirable position over the heads of equally good men who have borne the drudgery and hard work of inferior positions, hoping and expecting that when there was a vacancy in a better position they would have the preference.

In many stations the force is divided into a night gang and a day gang, the day gang going off as the night gang comes on, and vice versa. I do not know that this practice is as general now as it was formerly, but I never thought it was well adapted in central-station work. In the first place the hours are too long, and in the next place it does not give the best distribution of labor. The number of men in the station does not vary according to the load. The practice which we instituted several years ago, of bringing the men on one or more at a time, an hour or so apart, and letting them off in the same way, we find can be made to exactly meet the requirements of an uneven load, and enables us to rotate the different men of the same class through all the different shifts during the course of one or two months, thus making the work and the hours of all exactly alike in the cycle.

At the end of each week the schedule is made up for the week to come, for each of the different classes of operatives interested, and this is posted on Saturday night, so that as the men go off work on Sunday, they can see what shift each will have during the coming week. These schedules are altered from week to week, increased or diminished as regards the number of men, and changed in form to conform to the varying conditions of the load-curve. As we are not sure what the load will be from day to day, or a week ahead, we are obliged to provide men enough to take care of what we assume will be the reasonable maximum. It is, of course, impossible to meet the requirements exactly without breaking a man in two and using the pieces in non-consecutive times of the day, but with a little care and study it is possible to arrange the schedule to very nearly meet the exact requirements.

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*Abstract of a paper read before the annual convention of the National Electric Light Association at Chicago.

The greatest possibilities for saving or wasting about a steam plant are undoubtedly in the coal-pile, but as it is a dirty proposition, and many of its features are not well understood, the subject does not receive the consideration to which it is entitled. The average ambitious engineer will spend much time and care on his engine to be sure that the indicator cards are perfectly symmetrical; that the points of cut-off are equal; the release in time and that the compression rises to meet the admission in a smooth, rounded curve. This is proper and commendable, yet the same time spent in studying the conditions of combustion in his furnace might show him a way to make a saving in fuel fourfold greater than is possible in the final refinements of the indicator cards.

A fireman whose wages amount to, say, 20 cents an hour, will burn during that time fuel costing ten and fifteen times as much as his wages. It would not be possible by any sort of driving to save half of the wages, but it is readily possible by properly watching and instructing the fireman to save double his wages in coal.

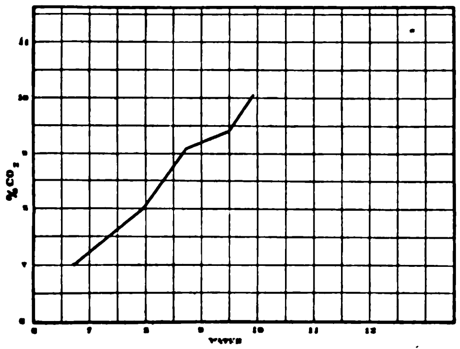


FIG. 1.

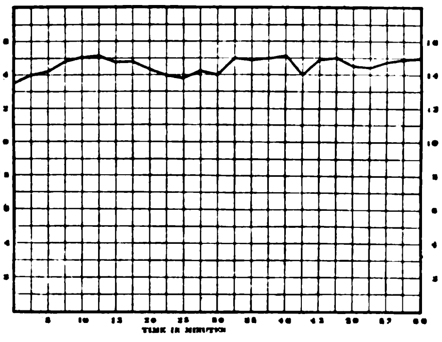


FIG. 2.

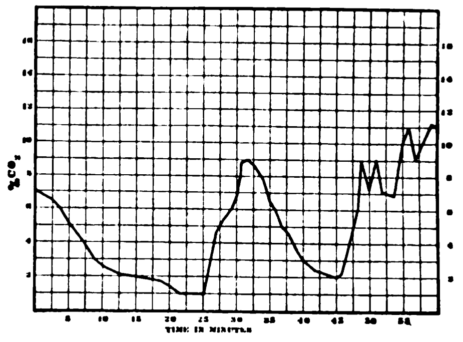


FIG. 3.

In the first place great care should be exercised in the selection of the coal to be used. I believe that the cheapest coal is that kind which has the greatest amount of combustible for the least amount of money, provided the furnaces are of the proper kind and ample in capacity to make the required amount of steam from them. The very cheapest kind of Illinois screenings costing less than $1.50 per ton will not have less than 10,000 B. T. U. per pound, and the very best of Eastern lump, costing $4 a ton, will not have more than 14,000 B. T. U. per pound. This means that for equivalent heating qualities the cheapest screenings cost about half as much as the high-grade coal.

Having selected the coal, the next problem is how to burn it properly. It is commonly understood that 12 lbs. of air are needed to properly burn 1 lb. of coal. It is also commonly supposed that in practice about twice this amount of air passes through the fire, but just how much actually passes, and under what conditions are the best results obtained, it is impossible to determine without making analyses of the flue-gases. Fortunately, this has now become a very simple operation, and one which can be performed and understood by any one competent to take charge of a large boiler-room.

These tests often show the most surprising and disappointing results. The analyses are made to determine the percentage of carbon dioxide in the flue-gases. Under perfect conditions it can run as high as 20 per cent, but it is not unusual to find samples running as low as 2 per cent of dioxide. This brings down the economy for two reasons. First, the gas in the firebox is diluted with an excess of cold air and cooled down; and secondly, the volume of gas per pound of weight being increased, it passes through the boiler more rapidly and does not give up so much of its heat. It is almost paradoxical that, within reasonable limits, the more the gases are cooled down in the furnace by the admission of excess of air, the hotter they will pass away from the boiler. The two causes of excess of air in the flue-gases are running boilers on too light loads and careless firing.

In a station where the load is much higher for a few hours than during the rest of the day, the tendency is to have too many boilers in service during the period of light load. The natural result is that the fires are run thin, the grates get bare in places, and a great volume of air is drawn in, only a small portion of which comes in contact with the fuel.

An engineer may be aware that he is not getting the results which his tests lead him to believe he should have, and yet, in a boiler-room where several men are working, it is exceedingly difficult to fasten the blame on any one of them unless he can examine the chips they make; in other words, the flue-gases.

In order to follow intelligently the work of the individual fireman, we have installed in our boiler-room a device called the econometer, through which is induced a small current of gas from a boiler breeching. The weight of this gas moves a pointer across a dial, and as the weight changes with the composition, the pointer indicates continuously the varying percentage of carbon dioxide in the flue-gas. From this device are run individual pipes to the breeching of each boiler, and all is so arranged that samples may be drawn from several boilers and tested in a few minutes, or a continuous test may be made of the performance of any one boiler.

Readings taken from this instrument at regular and short intervals when plotted form a curve which is a very comprehensive record of the conditions of combustion during the time of observation. A few of such curves I submit herewith. Fig. 1 shows the results of a test made to determine the relation between boiler efficiency and percentage of carbon dioxide. The results show that within the limits of the test the two are almost directly proportional. Fig. 2 shows the results of skillful and even firing. Fig. 3 shows what occurs when a fire is cleaned in a leisurely manner; first the dioxide dropped to 1 per cent, then followed a charge of coal which got the furnace in good working condition, but as the fire was not replenished during the next fifteen minutes, it burned so thin that it is doubtful if the boiler was making steam at all. The latter part of the curve shows the automatic improvement in the fireman as soon as he observed that he was under surveillance.

DISCUSSION OF MR. ABBOTT'S PAPER.

In answer to questions by Mr. Scovil, Mr. Abbott stated that the curves shown were the results of hand firing, and that the company purposed to install automatic stokers in the immediate future. Automatic stokers, he said, can be made to show almost any kind of results but do not require nearly so much skill to get good results as is required with hand firing. Mr. Doherty took issue with Mr. Abbott on the statement that coal having the greatest calorific value for a given cost should be used, Mr. Doherty's opinion being that the class of coal which will produce the greatest amount of steam for a given cost should be the basis of selection; many coals which are not high in specific calorific value are much higher in efficiency because they give a higher flame temperature and produce a greater activity in the furnace. In answer to a request from Mr. Cahoon for the details of his method of analyzing flue gases with the econometer, Mr. Abbott referred the question to Mr. A. Bement, who explained as follows:

If the conditions prevailing are those of a thin fire or a strong draught and the indication of carbon dioxide shown by the econometer is low, it is an indication of an excess of air; if, on the other hand, the fire is thick or the draught low, and the indication is low, it is proof of incomplete combustion. The reasons are in the first case the total volume of gases is increased owing to the large amount of air present and which is not used, causing the carbon dioxide to be small in amount in relation to the total volume; second, the carbon dioxide is less with incomplete combustion, because carbon goes to carbon monoxide instead of to carbon dioxide. If the indications of the instrument are irregular it shows an uneven condition which may be, and usually is, accompanied by both an excess of air and incomplete combustion. If the highest carbon dioxide obtainable in a furnace is 15 per cent and the instrument indicates less than this, it is apparent that something is wrong, and any change in firing conditions is immediately and automatically indicated.

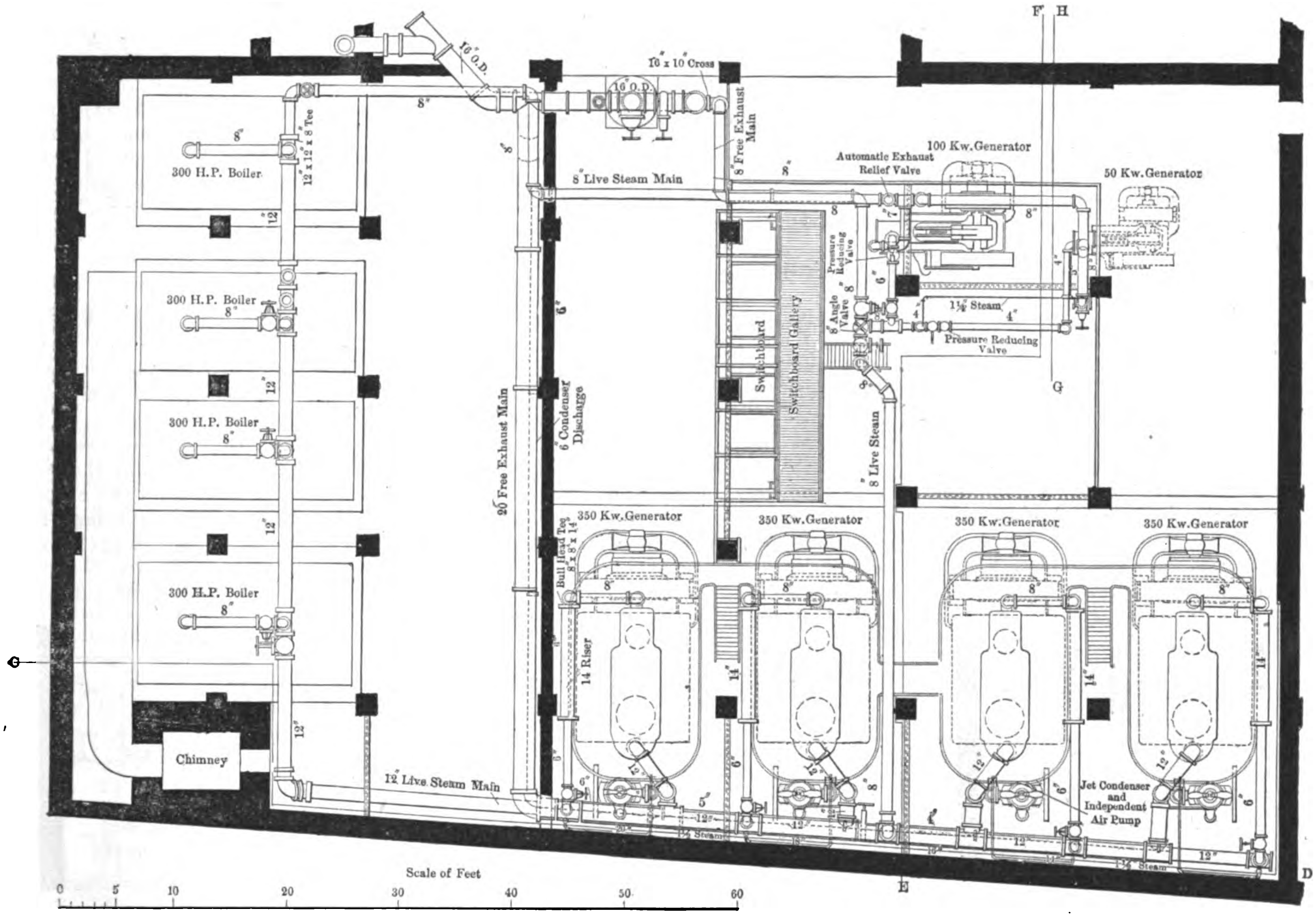

F
H
16" O.D.
16" x 10" Cross
16" O.D.
8" Free Exhaust Main
8"
8" Live Steam Main
12" x 12" x 8" Tee
300 H.P. Boiler
300 H.P. Boiler
300 H.P. Boiler
300 H.P. Boiler
Chimney
12" Live Steam Main
20" Free Exhaust Main
6" Condenser Discharge
Switchboard
Switchboard Gallery
100 Kw. Generator
Automatic Exhaust Relief Valve
50 Kw. Generator
Pressure Reducing Valve
8" Angle Valve
1½" Steam
Pressure Reducing Valve
8" Live Steam
G
Bull Head Tee 8" x 8" x 14"
14" Riser
350 Kw. Generator
350 Kw. Generator
350 Kw. Generator
350 Kw. Generator
Jet Condenser and Independent Air Pump
1½" Steam
D
E
Scale of Feet
0
5
10
20
30
40
50
60

FIG. 1.—PLAN OF WESTERN ELECTRIC GENERATING PLANT.

For a chemical analysis we use the absorbing econometer, a modified or improved form of the Orsatt, which I consider has some advantages. I have also used a method by which it was possible to gather a gas sample and make analysis for carbon dioxide and caroon monoxide at two-minute intervals. I found, however, that the method, which is excellent where there is little oxygen present, is not satisfactory when oxygen exceeds about 3 per cent. The absorbing econometer is a very simple instrument; it is used for carbon dioxide determination where the gravity instrument is not available. The gas is pumped into a measuring and absorbing chamber where it is confined and by the movement of a partition the gas is brought in contact with the reagent, the reduction in volume is indicated on a graduated tube by a water column at atmospheric pressure. This is the most rapid of all chemical instruments. I have been able by its use to determine carbon dioxide at one-minute intervals while riding on the front end of a locomotive, and also to make 75 analyses and 75 observations of temperature of escaping gases, and make a record of each, in 15 minutes.

The carbon dioxide determination is so easily and rapidly obtained that it is more useful than more elaborate analysis. We always employ the more elaborate methods of analysis where it appears that such are the best means to obtain the desired information, and these investigations would not be confined to the two carbon oxides and oxygen if there was occasion to go further, but would be extended to hydrogen and hydrocarbon compounds. The only rapid method of determining carbon monoxide that I am aware of is that which I employ. It is very expensive and rather difficult, and the cost of the apparatus was about $200, and while very interesting I consider that it can have no industrial application.

In answer to a question from Mr. White, of Cincinnati, Mr. Abbott stated that the cost of an econometer equipment such as the one used in the Chicago Edison station, for a station of ordinary size, operating two or three boilers, would probably be $175.

THE POWER PLANT OF THE NEW YORK FACTORY OF THE WESTERN ELECTRIC COMPANY.

The electric lighting and power plant of an electrical manufacturing establishment might naturally be expected to be of the highest character owing to the fact that a company of this kind would be inclined to take considerable pride in its own plant, built up of its own apparatus, as well as the fact that it could readily afford to put in the most expensive equipment, since the additional outlay would largely be expended in its own shops. In most cases electrical manufacturing establishments have grown so rapidly that the isolated plants consist of collections of machines of various dates, crowded into space originally intended for a much smaller equipment. The new factory of the Western Electric Company, on Bethune Street, New York City, now approaching completion, was, however, planned in its entirety before work upon it was commenced, so that all its parts are properly designed for the work which they will be called upon to perform for some time at least. The factory is as highly developed, organized and specialized as though it were a manufacturing establishment in a much older and more settled line of work, and possesses many points of interest for a description of which there is not sufficient space in these columns. The entire factory is contained in one building about 150x275 ft. in size, and with a height of 10 stories in one part and 13 stories in another part. This building, with a three-story annex, houses some 3400 employees on its 11 acres of floor space.

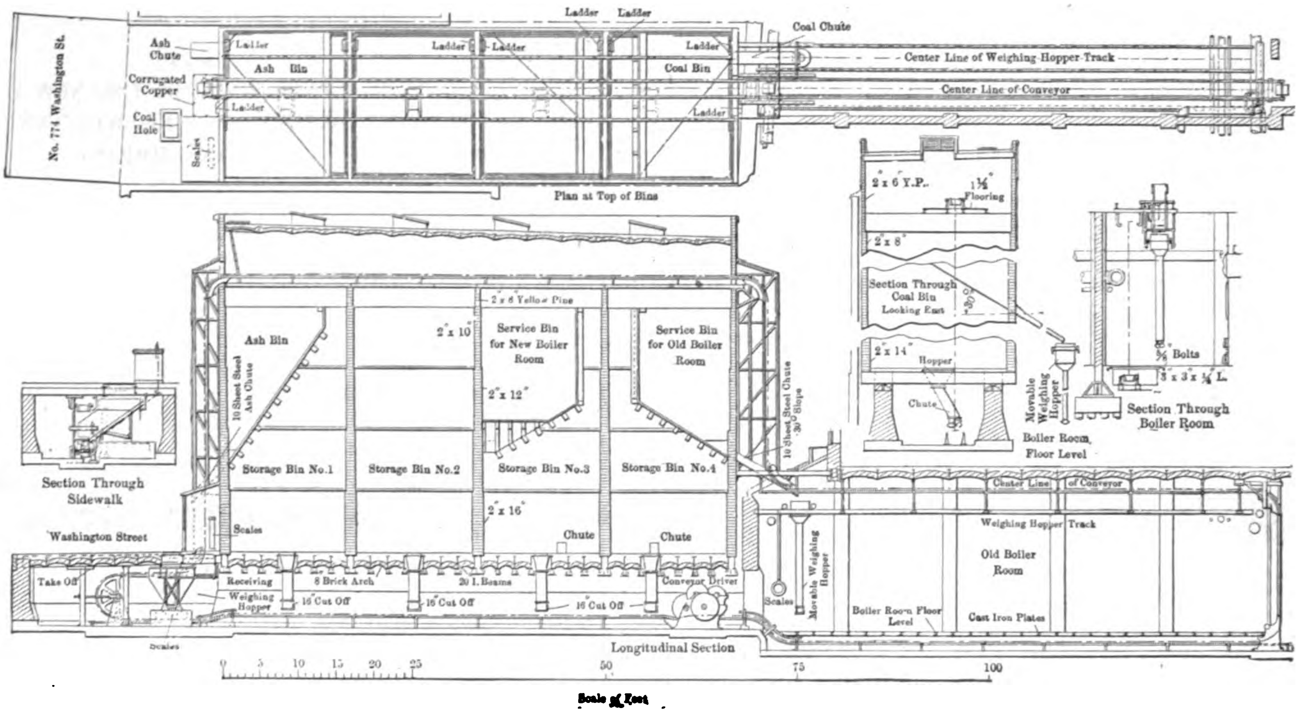

No. 774 Washington St.
Ash Chute
Corrugated Copper
Coal Hole
Ladder
Ash Bin
Coal Bin
Coal Chute
Center Line of Weighing Hopper Track
Center Line of Conveyor
Plan at Top of Bins
2 x 6 Yellow Pine
Service Bin for New Boiler Room
Service Bin for Old Boiler Room
Storage Bin No.1
Storage Bin No.2
Storage Bin No.3
Storage Bin No.4
Section Through Sidewalk
Washington Street
Take Off
Receiving
Weighing Hopper
8 Brick Arch
20 I. Beams
16 Cut Off
Conveyor Driver
Chute
Scales
Movable Weighing Hopper
Old Boiler Room
Boiler Room Floor Level
Cast Iron Plates
Weighing Hopper Track
Longitudinal Section
Section Through Coal Bin Looking East
Hopper
Boiler Room Floor Level
Section Through Boiler Room
Bolts
0 5 10 15 20 25 50 75 100
Scale of Feet

FIG. 2.—PLAN AND SECTIONS OF COAL STORAGE AND HANDLING PLANT.

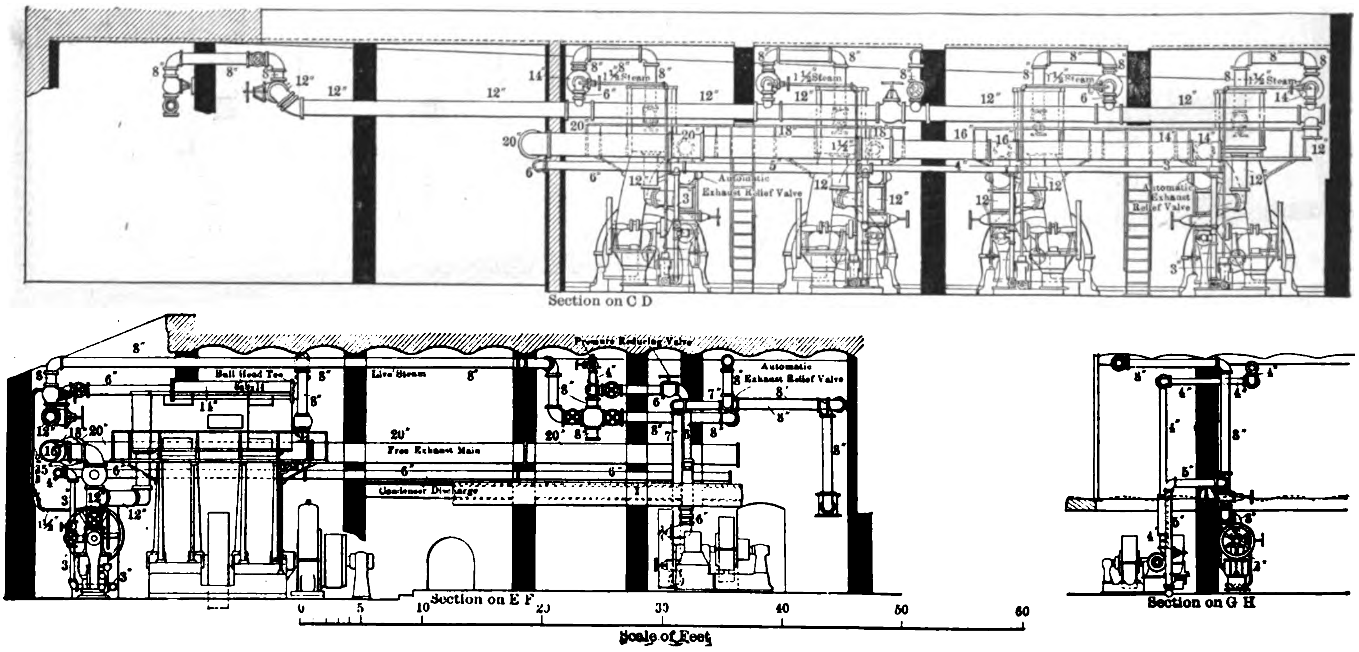
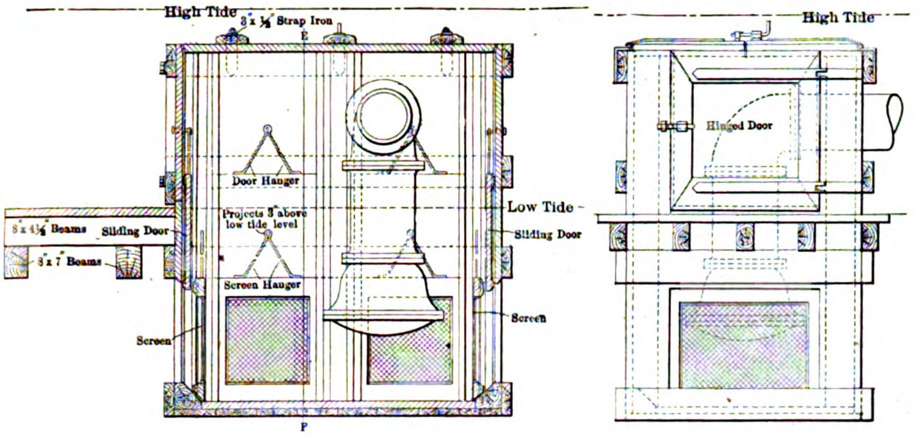

Section on C D
Steam
Automatic Exhaust Relief Valve
Section on E F
Pressure Reducing Valve
Ball Head Tee
Live Steam
Free Exhaust Main
Condenser Discharge
Automatic Exhaust Relief Valve
Section on G H
0 5 10 20 30 40 50 60
Scale of Feet

FIG. 3.—SECTIONAL ELEVATIONS OF THE POWER GENERATING PLANT.

The isolated plant which supplies electric current for lighting and all power in the building is probably the largest plant delivering its output to one building in the world. The rated output of its generators aggregates 1550 kilowatts, while that of the plant generally credited with being the largest in the world, viz., that of the Waldorf-Astoria Hotel, is only 1240 kilowatts. The plant is compactly arranged, being much more so than that of the Waldorf-Astoria Hotel, with its horizontal Corliss engines. In the Western Electric plant the largest units are four 350-kw. Western Electric multipolar generators direct coupled to Ball & Wood Corliss-type vertical cross-compound engines running at 150 r.p.m. In addition to these there are one 100-kw. and one 50-kw. sets to carry light loads and allow the large sets to be loaded up to their points of maximum economy. The large sets are designed with cylinders rather small for the rating, so that the maximum economy—which is obtained with a cut-off of 21 per cent—gives 90 per cent of the rated output, the frames and parts being maintained heavy to give smooth running and absence of heating even with considerable overload. The machines generate 120 volts, and, while they are rated at 2900 amperes, each will readily deliver 4000 amperes without straining the engines or causing sparking at the commutators.

The current is generated and distributed entirely on the two-wire 120-volt system, involving in a plant of this kind an unusually large amount of copper in the switchboard and distributing networks. This voltage was adopted in preference to one twice as high on account of the fact that the distance from the generators to the load is very short, making the feeder cross-section dependent on the heating limit rather than on the percentage fall of voltage. On this account the cross-section of the feeders is only twice as great as it would be with a 240-volt system, instead of four times as great, as would be the case if the feeders were sufficiently long to make the drop within them a factor in the regulation. There are used through the factory a number of

110-volt motors and elevators taken from the former plant on Thames Street, in New York City, and it was found cheaper to install the extra copper necessary for the 120-volt system than to rewind these motors for 240 volts and rebuild the controlling apparatus.

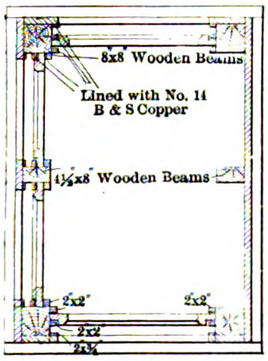


Section A. B.

View Looking North

FIGS 4 AND 5.—STRAINER CRIB FOR SUCTION PIPE.

The steam-generating equipment presents several interesting features. There are two boiler rooms, one of which has been in service for some time, the other being a new one recently completed and intended to supply another battery of engines which will be built later on to supply power for further extensions of the factory. The old boiler equipment consists of Babcock & Wilcox boilers with a rated steam-generating capacity of 1200 horse-power. The coal and ashes are handled by a Hunt conveyor on a novel system, which is best explained by reference to the accompanying diagram, Fig. 2. Coal is delivered from wagons to the conveyor through the chute shown under the street level, and is thence carried to any desired one of the storage bins, the combined capacity of which is 1000 tons. The conveyor continues under the fireroom floor of the older boiler room, in which floor there are hoppers through which ashes can be shoveled into it. These ashes are then carried by the conveyor to the ash bin shown in the drawing, from which ash bin they can be spouted to wagons in the street. Coal can be spouted from any one of the storage bins to the conveyor and carried by it to either one of the two service bins, one for the new and one for the old boiler room. From these service bins it is spouted to a weighing hopper in each fireroom. This weighing hopper is suspended from a truck on an overhead track by means of which it can be rolled along in front of any boiler and there emptied. By keeping the service bins full of coal, the capacity being about 100 tons each, the boilers can be supplied with coal by means of the weighing hoppers for a sufficient period to tide over any ordinary break-down of the conveyor.



Section C.D.

FIG. 6—PLAN OF STRAINER CRIB.

In order to provide infallible means of supplying the fireroom in case of a long-continued shut-down of the conveyor there are spouts from the bottoms of the storage bins through which coal can be shot into cars or wheelbarrows and carried in them to the boilers in either room. The coal bins are unique in that their walls are not built of steel framework and brick or tile arches, but are built of yellow pine planks laid flat, one on top of another, and spiked together after the manner formerly employed in the construction of grain elevators. This construction was adopted owing to the fact that the space occupied by the coal bin is narrow, making the thickness of a brick arch wall, combined with the spring of the arch, a serious loss of volume. The solid wooden wall gives a considerably greater percentage of the total width for storage purposes. The long side walls are held from bulging outwardly by the cross-walls between the several bins.

The new boiler room contains double-decked Babcock & Wilcox boilers with an aggregate rating of 1250 horse-power, the room having sufficient space for 1250 horse-power more. The room will also be fitted with a coal and ash-handling system similar to that in the old room, the weighing hopper in this case to be operated by a small winding engine, motor driven. The new boilers discharge their gases through Green economizers and are fitted with induced-draft blowers.

The live-steam piping is made extra heavy, with flanges welded on, the whole being tested up to 250 pounds pressure, the normal working pressure being 140 pounds. It will be noted from the plan of the old engine and boiler room, Fig. 1, that there is a ring main, including all of the boilers and two of the large engines, the other two large engines being supplied by a branch outside this ring, the smaller single-cylinder engines taking steam through Foster reducing valves designed to give them 100 lbs. pressure.

In the branch from the main to each of

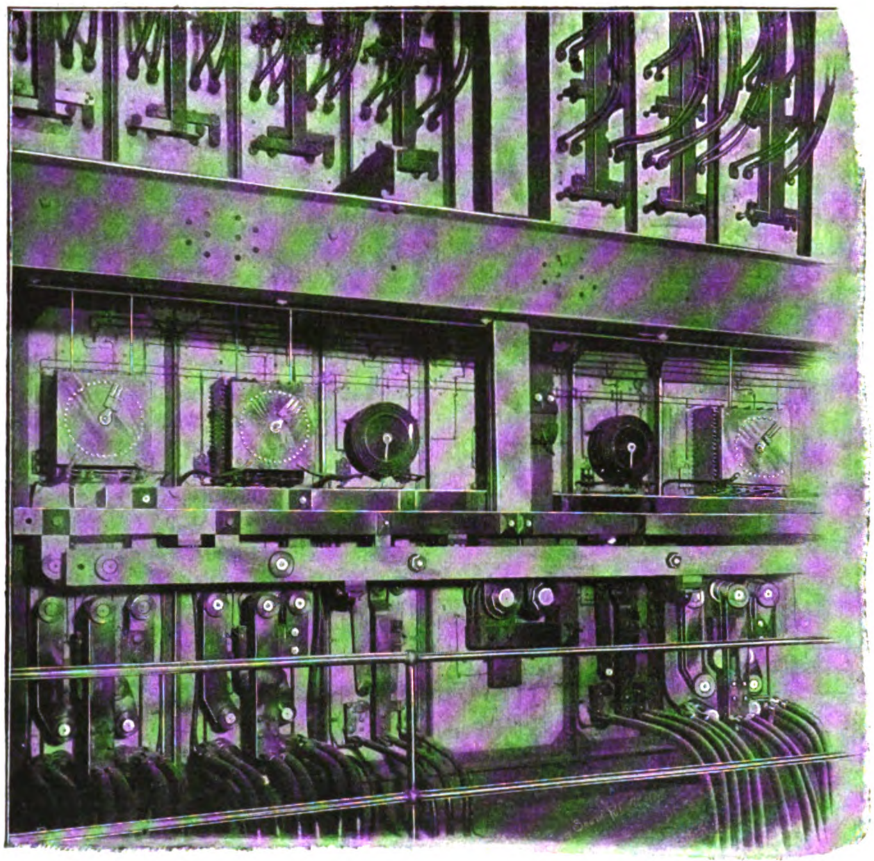


FIG. 7.—VIEW OF BACK OF SWITCHBOARD, SHOWING SINGLE-BOLT CONNECTIONS TO BUS-BARS AND INSTRUMENTS.

the large engines there is included a length of 14-in. pipe to act as a receiver and equalize the pressure near the engine. The steam passes from this receiver to a bull-head T, from one branch of which it rises and passes over and down to the engines. The lower end of this T is capped and dripped through the Holly system, serving thus as a sort of separator. Each branch to an engine starts vertically out of the top of the main, giving a flange in a horizontal plane at this point, another flange in a horizontal plane on the bull-head T at the engine end of the receiver, and another flange in a horizontal plane in the vertical drop to the engine throttle, a slight rotation of these three flanges readily taking up the expansion of the main. The right angle bend in a horizontal plane between the 14-in. receiver and the run from it to the engine give an opportunity to fasten the main permanently to the wall without danger of tearing this fastening loose when the main expands, so that the run to the engine is made at an angle.

Independent steam-driven Conover jet condensers and air pumps are used for the large engines, taking their water supply from a 14-in. injection pipe leading to the North River. The overflow is carried back to the river through a 16-in. discharge pipe.

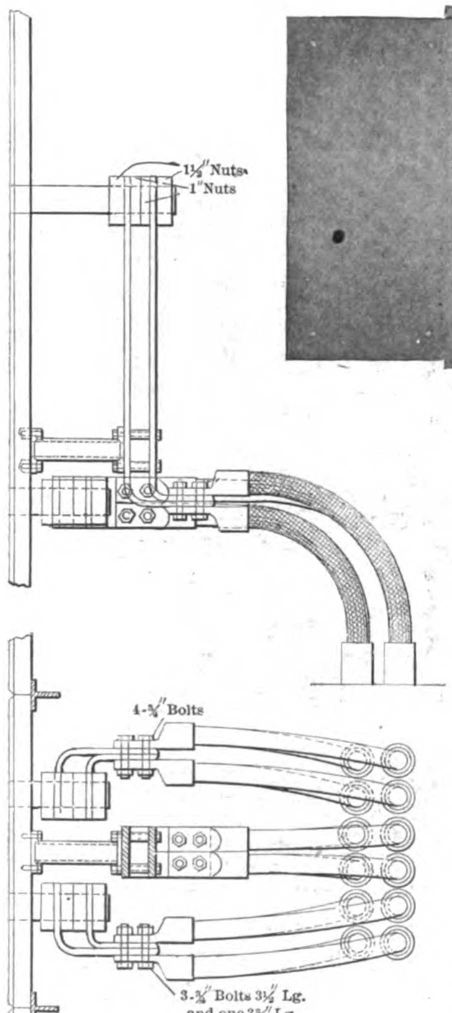


FIG. 8.—DETAILS OF SWITCHBOARD CONNECTING LUGS.

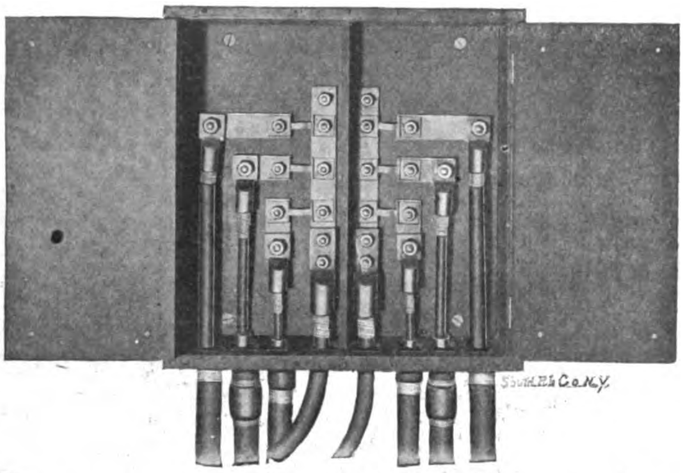


FIG. 9.—MOTOR OUTLET BOX.

The injection pipe ends in a rather novel form of strainer crib under the Wilson Line pier. As shown in Fig. 4, this crib has four doors, any one of which can be closed down when it becomes desirable to raise the corresponding strainer to clean it. The pipe is also ingeniously arranged to provide a means of getting at the foot valve. The flanged joint between the upper end of the elbow and horizontal run of the pipe can be broken, a bar can be inserted in place of one of the uppermost bolts in this flanged joint and the whole of the vertical section of the pipe can be swung around this bar as a hinge by means of a chain attached to the foot of the pipe. The side of the crib is fitted with swinging doors, as shown in Fig. 5, to allow the pipe to be swung around in this way to expose the foot valve.

There are no primary heaters between the main engines and the jet condensers, there being only an open heater taking the exhaust of the feed and air pumps. As noted above, the new boiler plant has an economizer through which the feedwater is pumped after being driven through the open heater. The economizer is by-passed in such a way that warm water can be taken from this discharge and mixed with the cold water entering it in case the auxiliary heater is out of operation or does not warm the water sufficiently to prevent the economizer from sweating. Between the exhaust of the main engines and the free-exhaust main there is no gate valve, simply the usual relief valve, so that there is no opportunity for blowing out the exhaust piping by shutting off both exhaust paths.

The switchboard is double-decked, the feeder panels being mounted above the generator panels and operated from the gallery. The board is built for 16,000 amperes, the bus-bars being laid out on a basis of 800 amperes per square inch, having, therefore, a cross-section of 20 sq. ins. The main panel in the center of the board has a large scale ammeter reading up to 12,000 amperes, and a G. E. recording wattmeter with the same capacity. The machine circuits enter the board through double-pole I. T. E. circuit-breakers of the laminated-wedge type, designed to carry 4000 amperes, there being no fuses in the dynamo circuits. The leads between each machine and the board consist of four 1,250,000-c.m. cables for each pole and four of the same size for the equalizer, filling, with the field wire, 13 conduits from the duct to each machine-pit. There is only one set of bus-bars on the board. In a plant of this kind with a heavy motor load made up largely of small machines, the load fluctuations are so small that as close regulation can be obtained as on Edison systems, rendering separate buses for lighting and power unnecessary. The usual output during the day varies from 7500 to 8000 amperes, by far the greater part of which is motor load, as the total numbe of lights connected in the building only aggregates about 7500.

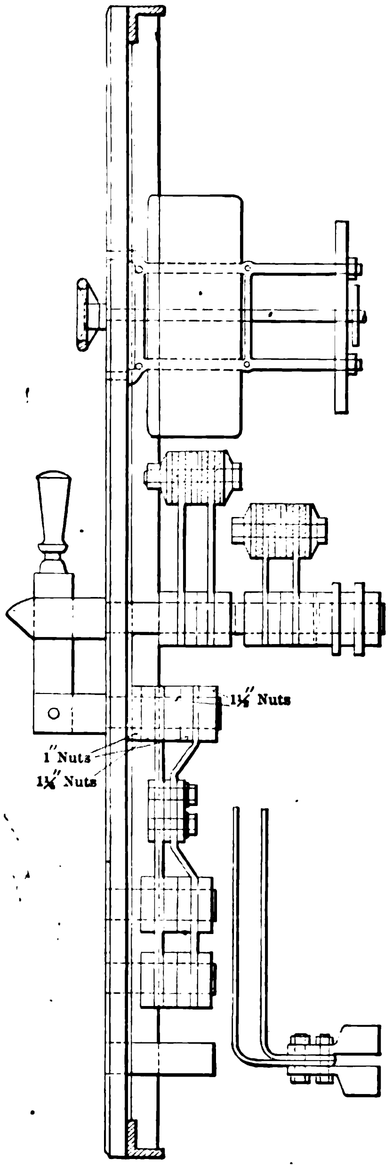


FIG. 10.—DETAILS OF SWITCHBOARD CONNECTING STRAPS.

The board is unique in that, with the exception of a General Electric integrating wattmeter on the main panel, there is no cast-copper of any size throughout the whole construction, even the nuts on the 4000-ampere switch studs and the lugs on the cables being made of rolled copper. The lugs are made up of short pieces of copper tubing, one end of which is flattened down and drilled for bolt holes, the cable entering the open end, as indicated in the accompanying detail, Fig. 8. In spite of their great area, the joints between the bus-bars and the branches running to and from them are tightened up with one bolt apiece, as indicated in the detail of this construction, Fig. 10. The bolt used is 1 in. in diameter, and its pull is spread over the whole joint by means of heavy cast-iron washers. The voltmeter bracketed to the edge of the board has no voltmeter switch, but is connected to plug receptacles which are made up of ordinary telephone spring jacks, adapted to receive four plugs; these four plugs are arranged to form a square and are diagonally cross-connected so that no matter how they are inserted into the receptacles there is no short circuiting.

Each of the feeder panels on the upper gallery of the board carries six fused switches, two with a carrying capacity of 500 amperes, two 300 amperes, and two 200 amperes. The iron-armored conduits all terminate in a long wooden box or compartment above the board, the walls of this box being lined with tin inside and out. From this box the feeders are continued down in circular-loom. The box provides an opportunity to jump a feeder from one to another section of the board when changes make this desirable, the feeder cables being left with sufficient slack to be moved over two or three panels, this slack being coiled within the tin-lined box. The openings in the bottom of the box, through which the circular-loom covered cables run down to the switch studs, are closed with split wooden caps.

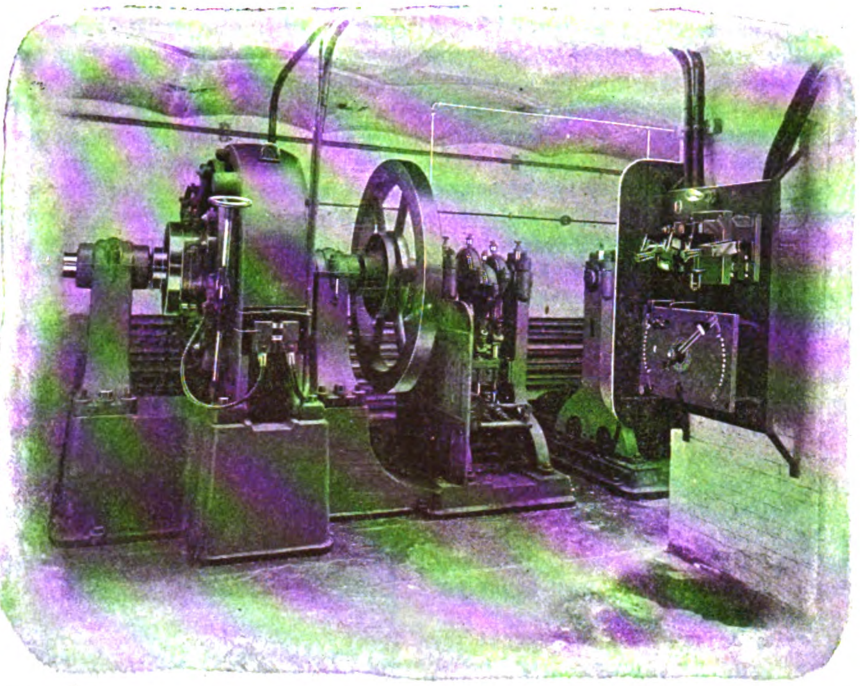


FIG. 11.—35-H.P. MOTOR DIRECT-CONNECTED TO A PUMP DELIVERING WATER TO LEAD PRESSES AT 6000 LBS PRESSURE. SPEED, 100 R.P M

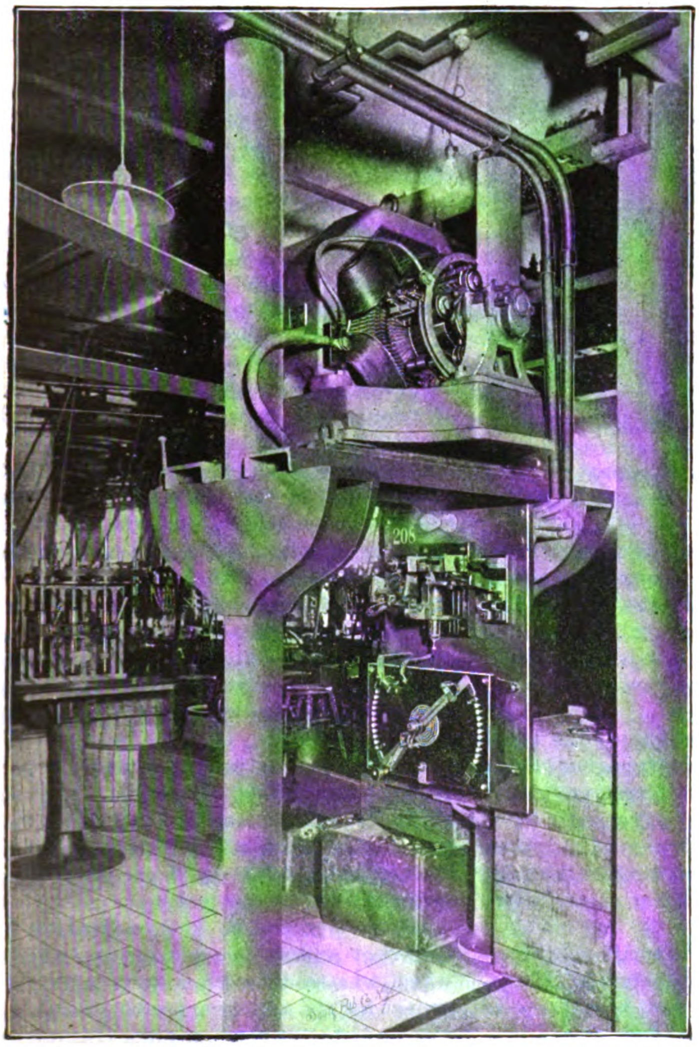


FIG 12.—A TYPICAL MOTOR EQUIPMENT

The interior wiring throughout the building is entirely in iron-armored conduits, with the exception of the lighting mains on the ceilings, which are run in molding. The conduits are carried on I-beam supports clamped in hangers, gripping the lower flanges of the I-beams of the floors. To provide lights wherever they may be wanted in the shops, the molding under the ceilings is run in the hollow of every arch, 3 ft. between centers, so that drops to lamps can be tapped off at any desired point in the rooms. In addition to the regular lighting circuits there are what are termed "patrol circuits," which are supplied by separate feeders from the engine room. These patrol circuits carry about 40 lights per floor, some of which are scattered through the rooms and some located over sinks, etc., the idea being that all the other lights except those on the patrol circuits, can be switched off at the engine room at five o'clock, the patrol circuits serving to light the employees out of the premises and to give sufficient light for watchmen at night. The molding of the patrol circuits is painted red to distinguish it from the regular lighting circuits.

The motors are supplied by separate feeders from the switchboard, which terminate in a special form of motor box such as that illustrated in Fig. 9. Each of these boxes provides outlets to three motors. It will be noted that there is a barrier between the two poles of the circuit. The arrangement of the motors is standardized in the unusually simple, substantial and durable form shown in the typical equipment in the accompanying il-

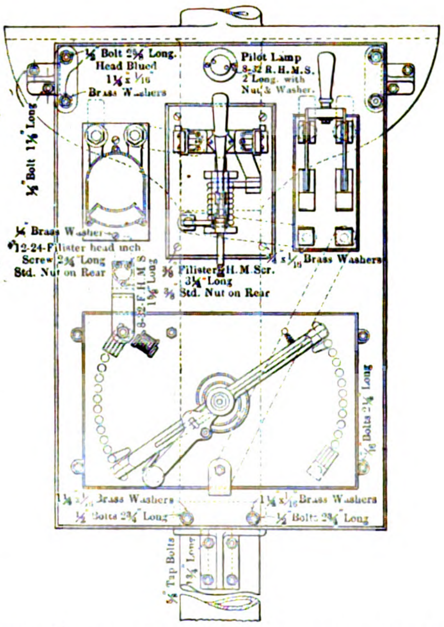


FIG 13 – DIAGRAM OF INDIVIDUAL MOTOR SWITCHBOARD IN FIG 12.

lustration. Two cast-iron columns are provided about 4 ft. apart, with brackets cast to them about 7 ft. above the floor. Laid over these brackets are two inverted channel irons on which the motor stands. Below the motor is a slate switchboard panel equipped with an I. T. E. circuit breaker, a Ward Leonard motor starter with no-voltage release, a Western Electric ammeter, a double-pole fused switch, and a pilot lamp connected to the source of supply to show whether current is or is not on the feeder. The motors are, in all cases, belted to line shafting, no individual motors being used on tools owing to the great number and small size of the latter.

The building is heated by means of hot water, which is in turn heated by the exhaust steam of the auxiliary engines, or live steam in case this exhaust is not sufficient. Without deducting the steam used for incidental purposes throughout the building, such as kettles, ovens, etc., the plant has shown the very satisfactory economy of 260 or 270 watt-hours per pound of pea coal.

All water for all uses throughout the building, except for condensing and boiler feeding, is obtained from artesian wells sunk under the property.

THE CHICAGO CONVENTION OF THE NATIONAL ELECTRIC LIGHT ASSOCIATION.

The first session of the convention was called to order Tuesday morning, May 22d, by President Carnes, who presented the usual opening address, in which he took occasion to congratulate the convention on assembling for the fourth time in the city of Chicago, where the most advanced workings and modern central station practice are so satisfactorily exemplified.

The first paper considered was the "Report of the Committee for Investigating the Photometric Values of Arc Lamps." Mr. Henry L. Doherty, chairman of the committee, presented the report, which set forth exhaustive investigations by the committee of the relative merits of direct-current open-arc lamps and direct-current and alternating-current enclosed-arc lamps. The committee also investigated the matter of light absorption by different kinds of globes and the deterioration in efficiency due to carbon deposits. The comparisons of various lamps was made by means of photometric measurements, as the title of the report indicates, and in the discussion following its presentation Mr. H. H. Wait pointed out the importance of making comparisons on a basis of effective illumination rather than from the standpoint of mean hemispherical candle-power. In series street lighting, he said, the different angles of greatest intensity with different types of lamps are in favor of direct-current open arcs for places where the distances between the lamps are short; direct-current enclosed arcs when the distance betweeen lamps is about 300 ft., and alternating-current enclosed lamps when the distance between lamps is greater than 300 ft. The advantage which the direct-current arc possesses as a source of light is partially or entirely compensated in series-lighting circuits by a comparatively low cost of generation and distribution when alternating current is used.

Mr. H. A. Wagner called attention to the need of standardization of enclosed arcs. In series open arcs there are the standard lamps known as 2000 c.p. and 1200 c.p., which are universally considered as requiring 9.6 amperes and 6.8 amperes respectively, but in enclosed-arc lamps, particularly those used on a constant-potential circuit, no attempt has been made to standardize the wattage. Alternating-current arcs, as a rule, show smaller power consumption than direct-current arcs, although a greater wattage is necessary for a given candle-power in an alternating-current arc than is required by a direct-current arc. The average consumption, for example, of the direct-current arc mentioned in the committee's report was about 525 to 550 watts, while the alternating-current arcs considered only consumed about 450 watts. For a fair comparison this condition should be reversed, if anything.

JAMES BLAKE CAHOON.
Newly Elected President of the Association.

Prof. C. P. Matthews offered the opinion that the reason manufacturers do not use higher wattage for alternating-current lamps is that the current required for a given wattage is considerably greater than that required by a direct-current lamp on account of the power factor of the alternating-current lamp.

Mr. H. W. Gilman stated that 25 alternating-current constant-potential lamps, passing 7½ amperes, had been tried in Atlanta for three months in comparison with ordinary open arcs, and that the Board of City Lighting of that city, as a result, had approved an arrangement for the installation of about 700 of the alternating-current lamps. These lamps required from 480 to 500 watts at their terminals.

Mr. Gilchrist of the Chicago Edison Company expressed the opinion that for commercial lighting a lamp of smaller power consumption, say 350 watts, was preferable to a high-watt lamp.

At the second session on Tuesday afternoon the first paper read was one by Mr. H. J. Frith of Watseka, Ill., on "Exhaust Steam Heating." The paper was in advocacy of operating a hot-water system in a manner similar to that described by Mr. Yaryan at the recent meeting of the American Society of Electrical Engineers. The system advocated by Mr. Frith consists of heating the water by means of exhaust steam at the station and distributing it through a single-pipe closed system, in which all the services are in series with each other.

Mr. F. A. Copeland of La Crosse, Wis., added to the paper a description of the system which is in operation by his company at La Crosse. This system is the Yaryan two-pipe arrangement, the fundamental features of which were described in the May number of the American Electrician, and supplies about 33,000 ft. of piping, ranging in size from 5 ins. to 8 ins. The system is patronized by 39 customers, the maximum distance of supply being 1¼ miles from the station. There is no pressure on the return pipe and a pressure of 45 lbs. per square inch on the supply pipe to lift the water to the highest radiator, which is about 100 ft. above the station level. The radiating surface installed is about 1 sq. ft. for each 35 cu. ft. of space to be heated. For a 10-room house about 600 to 700 sq. ft. of radiating surface is required, sufficient to obtain a temperature of 70 degs. F., with an outdoor temperature of 30 degs. below zero, the water being heated to 190 degs. The average drop of temperature between the supply and return pipes is 35 degs., and the loss by radiation in the main is estimated at 6 degs. Usually half of the electric-light steam plant is run condensing, the exhaust steam from the other half being used to heat the distributed water. There is a day load of about 150 horse-power at the switchboard, and this runs up to 550-600 horse-power at night. Mr. Copeland expressed doubt as to the advisability of operating the heating system where there is no day load.

The next paper read was one by Mr. W. L. Abbott, Chief Operating Engineer of the Chicago Edison Company, on "Central Station Economies;" this paper and the discussion following it are abstracted very fully on another page.

The Committee on Standardization of Electrical Apparatus presented its report, which was read by Prof. Robb, and recommended the official approval of the report made by the corresponding committee of the American Institute of Electrical Engineers. The report stated that the Institute committee and a committee of the American Society of Mechanical Engineers are working together with a view of securing standardization of sizes, speeds and shaft diameters of direct-connected engines and generators. The report of the committee was approved and the session adjourned.

The Wednesday morning session opened with a paper on "Uniform Accounting," by Mr. Jas. B. Cahoon of Syracuse, N. Y. Mr. Cahoon pointed out that central station men are face to face with a choice between the two alternatives of municipal ownership and private ownership under state regulation. In order to avoid municipal ownership he said that it was necessary to accede to state regulation of central station companies, submitting once a year a complete statement of everything, costs as well as receipts, and making public the profits of the plant.

In the discussion of the paper, Mr. Samuel Insull, speaking of depreciation, brought out forcibly the disaster awaiting companies whose books indicate exaggerated profits, which only serve as a strong argument in favor of municipal ownership. Mr. Insull agreed that there was no objection to the publication of accounts, there being everything to gain and nothing to lose, as central station companies are not in a business yielding large returns. Mr. Insull further said that he had no personal objection to municipal ownership, provided it resulted in giving the operating companies their money back and a fair return for the risk they had undertaken in installing their plants. With reference to the subject of depreciation, Mr. Insull, in answer to a question as to what he would do if his company used a 50-light arc dynamo, costing $2000, for four years, and then sold it for $250, and put in a 100-light machine, costing $4,000, replied that he would charge off the difference of $1750 as depreciation against the operating account and charge up $2000 for increased facilities against construction account, provided no depreciation had been charged on the old machine during its four years' use.

Mr. Samuel Scovil of Cleveland offered a resolution declaring the sense of the Association to be that the president and executive committee should appoint a committee to formulate a system of uniform accounting, and that this committee should proceed with its work as speedily as possible so that its report could be discussed intelligently at the next annual meeting of the Association. The resolution was passed and the morning session closed.

The Wednesday afternoon session was opened with a paper by Prof. W. L. Robb of Hartford, Conn., on "Series Enclosed Alternating-Current Lights for Street-Lighting Service," which consisted mainly of a description of the constant-current transformer system in use in Hartford, and a comparison of this system with others. Prof. Robb, in his paper, stated that the lamps were trimmed only once in six days and that one trimmer with a horse and wagon can easily take care of 500 lamps. At the Hartford rate of wages the trimming of the enclosed alternating-current lamps costs $2 per lamp as against $8 a lamp when open arcs were used. The cost of carbons per lamp per year is $1.50, against $5.84 previously paid for carbons for the open arcs. The cost of inspection is unchanged. The breakage of inner globes averages less than two globes per year per lamp, or about thirty cents per lamp per year. In the discussion which followed the reading of the paper, Prof. Robb, in answer to questions, explained that the annual cost of $2 per lamp included the cost of a horse and wagon, and also the cost of cleaning globes at the station.

Mr. M. E. Turner of Cleveland pointed out that the best test of street lighting is not the photometric test for candle-power; the best method perhaps is to take lamps of equal wattage and judge by the eye of the comparative illumination. In Cleveland six lamps of the same wattage were hung on the streets on two spans, three lamps to a span; two of these were open arcs, two direct-current enclosed arcs, and two alternating-current enclosed arcs. Each lamp was controlled by its own switch. About twenty-five or thirty electric light men inspected these lamps at night, ninety per cent. of whom were previously sure that the direct-current lamps would give the most light. After they had looked at the lamps, had them turned off and on, and read newspapers by the light, all of the men except two decided that the alternating-current lamps were giving more light than the others, either open or enclosed.

On another occasion 15 alternating-current lamps were hung about 300 ft. apart and some of them were equipped with opalescent inner globes and the others with clear inner globes. The conditions were rather favorable for comparing one of the lamps with a clear inner globe with one which had an opalescent inner globe; there was an obstruction in the street just midway between the two lamps in the form of two posts, so located that the shadow cast by the post standing in the range of the lamp having the opalescent inner globe crossed over the shadow cast by the other post standing in the range of the lamp having a clear inner globe, indicating superior illumination through the opalescent globe. Mr. Turner deduced from this experiment that at a distance of 150 ft. from a lamp the street illumination is better with an opalescent inner globe than with a clear one, and that at distances less than 150 ft. the light from a clear inner globe is better than that from an opalescent inner globe, though the diffusion is not so great.

Mr. H. W. Hillman of Schenectady stated that the Utica Electric Light Company claimed a saving of $9.74 per lamp per year in trimming expenses by the use of enclosed lamps as compared with open arcs; one trimmer handles 600 lamps. The company uses a revolving brush driven by a motor, and located over a sink for cleaning the inner globes, and one man has made a record of cleaning by this means 125 inner globes in one hour and twenty minutes.

Mr. Wm. F. White of Cincinnati pointed out that the apparent discrepancy between results observed by Mr. Turner with opalescent and clear inner globes and the results usually claimed, was due to the fact that a 6.6-ampere direct-current arc was compared with a 7½-ampere alternating-current arc. Mr. White argued that hemispherical candle-power was of no value whatever in considering street lighting. What is desired is a lamp that will give uniform illumination along the street to be lighted; the less the light under the lamp the better, within reasonable limits. In street lighting the lamp which gives horizontal illumination rather than a large mean spherical candle-power is preferable, and this condition is met by the alternating-current arc. Actual photometric curves from a 7½-ampere alternating-current enclosed arc, a 6.6-ampere direct-current enclosed arc, and a 9.6-ampere direct-current open arc, show that with all of the lamps at the same height in the street, say 25 ft., at a certain distance from a point directly under the lamp the candle-power curve of the direct-current enclosed arc will cross that of the direct-current open arc; at a certain greater distance the candle-power curve of the alternating-current arc will cross that of the direct-current open arc, and at a still greater distance the curve of the 7½-ampere alternating-current enclosed arc will actually cross that of the 6.6-ampere direct-current enclosed arc. These results, which have been shown by actual photometric tests carried out at distances of 300 ft., indicate that the alternating-current lamp is the best. Mr. White recommended the use of reflectors in connection with alternating-current lamps.

Mr. H. A. Wagner of St. Louis drew attention to the fact that most of the previous comparisons in which efficiency was mentioned were taken from tests made on 6.6-ampere alternating-current arcs and that a 7½-ampere alternating-current arc has a higher efficiency in candles per watt than the 6.6-ampere arc; hence he argued that the comparisons would be still more favorable to the alternating-current arc if they had been made with 7½-ampere lamps.

At the close of this discussion a resolution was adopted recommending the passage by Congress of a bill providing for the establishment of a national standardization bureau, the equipment of which should include a laboratory and a function of which would be to furnish authoritative standards.

Mr. Henry L. Doherty of St. Paul, Minn., then read a paper on "Equitable, Uniform and Competitive Rates." The paper emphasized the objectionable features of flat rates, uniform meter rates, meter rates based on quantity of consumption, meter rates on a minimum charge, meter rates based on the length of time of maximum capacity used, maximum demand meter rates, and meter rates varying according to the time of day at which current is used. The paper described a new system of charging which is to be put into service in a central station. The system consists of making a charge for "readiness to serve" and an additional charge per kilowatt-hour for the actual service. The charge for "readiness to serve" is based on the maximum demand of the consumer, and fuses or some other device will be used to prevent exceeding this demand. There is to be a fixed charge of $3 per year per consumer, $1.50 per year per lamp and a meter rate of five cents per kilowatt-hour.

At the Wednesday evening session Mr. H. G. Reist of Schenectady delivered a lecture on "Alternating-Current Generators," in which he outlined the development of alternating-current machines from the rotating armature to the rotating-field types; Mr. Reist also described the rotating-field construction adopted by the General Electric Company and explained the compensated-field machine of that type.

At the Thursday morning session the Committee on Grounded Circuits presented its report, in which it recommended the grounding of the neutral wire of three-wire low-potential systems as a measure of safety. The committee further stated that while the permanent grounding of one side of the secondary circuit of a transformer is not an absolute preventive of accidents, yet it is considered a step in the right direction, and if adopted will add greatly to the safety of the public.

The election of officers just before the adjournment of the convention resulted as follows: President, James Blake Cahoon of Syracuse, N. Y.; First Vice-President, Louis A. Ferguson of Chicago, Ill.; Second Vice-President, W. Worth Bean of St. Joseph, Mich.; Executive Committee Members, Chas. B. Hunt of London, Ontario, Ernest H. Davis of Williamsport, Pa., and Henry L. Doherty of St. Paul, Minn.

THE INDEPENDENT TELEPHONE ASSOCIATION'S FOURTH CONVENTION.

The fourth annual convention of the Independent Telephone Association of the United States, which was held at Cleveland, Ohio, June 12th to 14th, inclusive, seems to have been the most satisfactory one since the inauguration of the association. The convention was called to order a few minutes after noon on June 12th, and after the roll-call Mr. James B. Hoge, secretary of the United States and the Cuyahoga Telephone Companies, delivered the address of welcome. Tuesday afternoon was given up to an examination of the exhibits, and on Tuesday evening the local independent telephone companies gave a reception at their quarters in the upper floor of the Electric Building.

At the Wednesday morning session President James M. Thomas delivered the usual annual address, in the course of which he pointed out that there are less than 2,500,000 telephones in operation in the United States, counting both the Bell and independent systems, and expressed the belief that the number could be increased to 7,000,000 telephones at reasonable prices. President Thomas also pointed out that since the expiration of the Bell controlling patents more than 3000 independent exchanges had been established, having nearly 1,000,000 telephones connected up.

At the conclusion of President Thomas's address, Mr. J. B. Ware, general manager of the Citizens' Telephone Company of Grand Rapids, Mich., read a paper on "Toll Line Traffic." Mr. Ware advocated the adoption of interstate rates based on air-line distances, and a uniform time unit. Among the advantages to be gained by such rates would be the ability to determine the toll between towns in different states by simply applying a scale to a map. The time unit advocated was three minutes. Exception would be naturally made as to rates between large cities and very important towns. In considering the distribution of the toll fees the exchanges' share should be first determined. This share should compensate for all toll service, both "in" and "out," and the settlement should be based upon business originating at the exchange or station, that is to say, the "out" business. Mr. Ware believes a fair arrangement would be 15 per cent commission to toll offices and 25 per cent to exchanges, with a maximum fee upon any one message of 10 or 12 cents.

Another argument in favor of the air-line rate is that under existing conditions the toll lines may or may not be air lines, and even where air lines exist messages may have to be sent over a circuitous route in order to save time. Under such circumstances the actual mileage would be difficult to ascertain and the arrangement of the settlement would be clumsy. Mr. Ware also advocated settlements between companies direct for all business done over two companies' lines, and the establishment of a clearing house in each state to deal with settlements for messages over three or more lines within the state, a general clearing house taking care of all interstate business. By a judicious grouping of states, he said, all messages over three or more lines can go with the greatest advantage to one central office, which might well also be at the interstate clearing house. Throughout his paper Mr. Ware laid particular stress upon the need for uniformity in details as far as practicable.

Mr. Edward L. Barber read a paper on "Telephone Developments," which consisted of a comprehensive and interesting review of the growth of the telephone industry and the improvement in the service and in the apparatus employed.

Mr. Hugh Dougherty, President of the United Telephone and Telegraph Company, Bluffton, Ind., then read a paper on "Independent Telephone Investments," in which he argued the necessity of telephone service to the business world and discussed the rates charged for exchange and toll-line service, character of construction and equipment, and the relation tween the benefit to the user of the telephone and the increase in the capital of the exchange. Mr. Dougherty pointed out that arbitrary exchange and toll-line rates were disadvantageous; the rates should be made, he said, to fit local conditions. The greatest mistake made by the independent companies so far has been bad construction.

Mr. Dougherty's paper was followed by an address from Mr. C. W. Kline, president of the Interstate Telephone & Telegraph Company of Philadelphia, on "Our Duty to One Another," in which Mr. Kline pointed out the necessity for co-operation and mutual support on the part of the independent companies.

A paper on "Telephone Construction," by Mr. Jas. E. Stewart, Chief Engineer of the Telephone, Telegraph & Cable Company of America, was then read by Mr. Van Nostrand, Mr. Stewart being absent.

The election of officers, which took place on the last day of the Convention, resulted as follows:

President: James M. Thomas, Chillicothe, Ohio.

First Vice-President: H. C. Young, Columbia, Pa.

Second Vice-President: C. E. Stinson, Rochester, N. Y.

Third Vice-President: H. E. Teachout, Des Moines, Iowa.

Secretary and Treasurer: S. P. Sheerin, Indianapolis, Ind.

First Assistant Secretary-Treasurer: R. F. Johnson, Saginaw, Mich.

Second Assistant Secretary-Treasurer: S. E. Wayland, Wilkesbarre, Pa.

Advisory Board: Hugh Dougherty, Bluffton, Ind.; H. D. Critchfield, Mount Vernon, Ohio; E. B. Fisher, Grand Rapids, Mich.; W. H. Deering, Boone, Ia.; W. B. Seaton, Ashland, Ky.; L. A. Frazee, Connersville, Ind.; George W. Beers, New York, N. Y.

Executive Committee: Illinois, W. W. Toby, Danville; Indiana, L. A. Frazee, Connersville; Iowa, W. H. Durin, Cedar Rapids; Kentucky, W. B. Seaton, Ashland; Michigan, J. B. Ware, Grand Rapids; New York, W. S. Eckert, New York; Ohio, Ed. L. Barber, Wauseon; Pennsylvania, S. E. Wayland, Wilkesbarre; Virginia, C. E. McClure, Richmond; West Virginia, John H. Grogg, West Union; Wisconsin, Richard Valentine, Farsville.

A complimentary banquet in the evening at the Colonial Hotel was an elaborate affair, over 400 tickets being issued. Mr. H. D. Critchfield was toastmaster and proved fully qualified for his duties. The banquet was the farewell feature of the Convention.

Comparison of Open and Enclosed Arc Lamps

To the Editors, American Electrician;

Sirs:—With reference to the table of operating expenses in my article in the June issue, it may be well to point out that the costs for alternating-current lamps are higher than for the direct-current lamps, partially on account of the intrinsically shorter life of the carbons at the same wattage, and partially on account of the customary practice of running the alternating-current lamp at a higher wattage to give the same amount of light as competing direct-current lamps. Furthermore, a slight increase is allowed for extra cleaning of the alternating-current lamp globes and the globe breakage is increased on account of the extra handling; also, the cored carbons are, of course, slightly more expensive. If the lamps are run at the same wattage and the globes are not cleaned during the run, the cost will come nearly to that of the direct-current lamps.

H. H. Wait.

Chicago, Ill., June 1, 1900.

Among Our Foreign Contemporaries.

Alternating-Current Wattmeter.—It is well known that in wattmeters based on the principle of Ferraris, there must be a phase difference of exactly 90 degs. between the magnetic fields produced by the main current and the shunt current; if this condition is not fulfilled, the wattmeter gives wrong indications of the power in a circuit in which the current is not in phase with the e.m.f., and the indications are the more incorrect the greater the phase difference. Therefore, for such instruments, devices producing a phase difference of 90 degs. between the two magnetic fields are of great importance. A recent issue of the "Elektrotechnische Rundschau" gives a description of a device made by Siemens & Halske which enables one to adjust with precision the strength of the shunt current, and independently to also produce an exact phase difference of 90 degs. In Fig. 1, m and n are the coils producing the main current field; ce and fd the coils producing the shunt current field. The latter coils are connected with non-inductive resistances, ed, cf and ef, like a Wheatstone bridge, ef being the diagonal resistance.

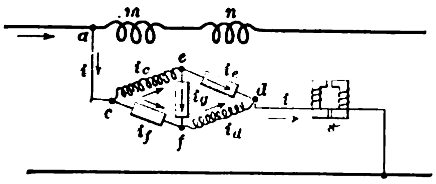


FIG. 1.—WATTMETER.

This bridge, connected in series with the induction coils, is connected across the conductors of the main circuit. The strength of the shunt circuit field is adjusted by the variation of the resistances, cf and de, which are best made equal. The phase difference of 90 degs. is produced by adjusting the diagonal resistance, ef; by increasing or decreasing the same, the phase difference is decreased or increased, respectively.

New Measuring Instruments for Alternating Currents. — According to the "Elektrotechnische Zeitung," Dr. Gustav Benischke of the General Electric Company of Berlin has devised some new measuring instruments for alternating currents which he exhibited and described in a recent meeting of the Electrical Society of Berlin. They are of the dynamometer type, with magnetic damping. The general scheme is shown by Figs. 2 and 3, one showing a vertical, the other a horizontal cross-section. A movable coil, B, is mounted on a spindle, A; its deflection is opposed by springs and accomplished by a fixed coil, F. The spindle, A, of the movable coil is provided with a pointer, Z, and an aluminum disc, R, the form of which is shown in the horizontal section; the extreme edge of this aluminum disc oscillates between the poles of permanent magnets, D, which damps the oscillations exactly as in a Thomson watt-hour meter. The dynamometer is surrounded by a laminated iron mantle, E, which is so formed that the magnetic lines of force pass through it, as indicated in Fig. 3 by dotted lines, without touching the damping magnets, D, so that the damping magnetism is not disturbed. The central part in which the movable coil oscillates is free of iron, so that there is a high reluctance air-gap in the magnetic circuit. The simplest of these instruments is a voltmeter; the fixed and the movable coils consist of relatively small copper wire and are connected in series; in an instrument measuring up to 125 volts, the resistance of the fixed and movable coils together is 130 ohms, and that of the rheostat is 2000 ohms, so that the current is a little below 0.06 ampere.

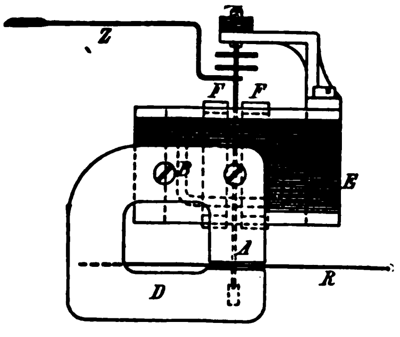


FIG. 2.

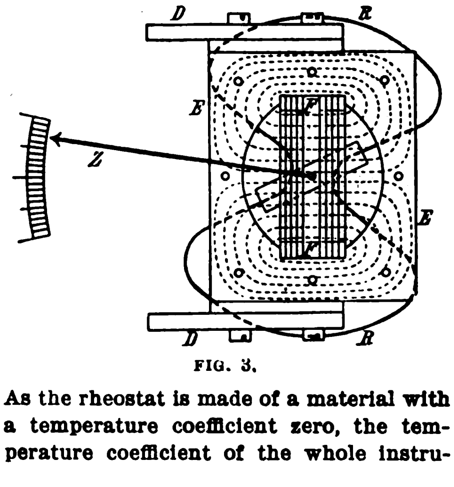


FIG. 3.

As the rheostat is made of a material with a temperature coefficient zero, the temperature coefficient of the whole instrument is 0.0024, if that of the copper coils is 0.04; so that the instrument is practically independent of the temperature.

In the wattmeter the fixed coil is in the main circuit and the movable coil is in shunt; the fixed coil consists of two windings, the four ends leading to a small switchboard mounted on the instrument so that they may be connected in series or in parallel, by means of two plugs, to be inserted in the conical openings 1, 2, 3, 4, shown in Fig. 4, where H and H are the terminals of the main circuit. By inserting one plug in 3, the two windings are connected in series; by inserting two plugs in 2 and 4, the two windings are connected in parallel and by inserting one plug in 1, the instrument is short-circuited, which is of importance when starting up an induction motor, as the current may be three or four times the normal current and endanger the instrument. The terminals for the shunt coil are N_1, N_2, N_3. At N_1 there is a movable hook, by means of which this terminal can be connected direct with the main circuit; this connection must be made for measurements in high-tension circuits, lest too great differences of potential occur in the instrument between the fixed and the movable coil. In order to get two different ranges of voltage, there are two rheostats, and the two terminals N_2 and N_3. Therefore this instrument has four different measuring ranges without external auxiliary apparatus. He shows analytically that the readings of the wattmeter are practically independent of the phase difference in the main circuit, so that they are practically correct even in measurements of the no-load loss of transformers; this is because the reactance of the shunt coil is extremely small compared with its resistance. He also shows that, although theoretically the readings depend upon the frequency, they are practically independent of it for the reason just mentioned. He found the differences of the readings with alternating current of 50 periods and with direct current to be very small; he also states that the wave form exerts practically no influence, and that as the magnetic circuit is far from being closed the magnetization of the iron is very small and there is no appreciable disturbance from hysteresis.

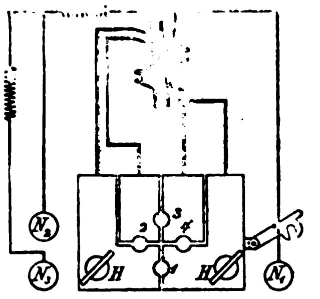


FIG. 4.

In the ammeter the fixed coil is supplied with the current to be measured and is connected in series with a resistance; in parallel with this resistance is connected the movable coil, as shown in Fig. 5. This is similar to the arrangement in the well-known direct-current shunted ammeters of the Weston type; the difference is that the field is not furnished by a permanent magnet, but by the fixed coil in which flows current to be measured. Evidently the field obtained by this method is much weaker than that of a permanent magnet, so that the resistance is to be chosen much larger, in order to get a greater difference of potential at the terminals of the shunt coil. The temperature coefficient of such ammeters cannot be made zero. Dr. Benischke states that the differences between the readings with continuous and alternating currents are below 0.2 per cent. He obtained nearly as good results with his voltmeters.

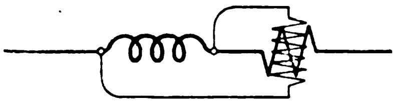


FIG. 5.

Electrolysis by the Return Currents of Railway Lines.—The old question of the electrolytic ruin of water and gas pipes by stray currents from electric railway tracks forms the subject of a long article by Prof. J. Teichmueller in a recent issue of the "Elektrotechnische Zeitschrift;" Prof. Teichmueller gives a systematical and critical summary of the different methods which have been proposed. Two of these methods are illustrated by Figs. 6 and 7. The e.m.f. of an auxiliary source of current is used to make the polarity of the rails always positive against the tension of the pipes, so that currents may flow from the rails to the pipes, but not from the pipes to the rails. These methods have, however, not proved successful in practice, as it is impossible to prevent the currents to leave the pipes after they have entered them; the author of the present article therefore speaks strongly against these methods.

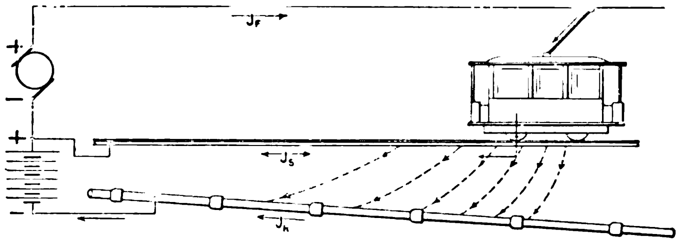


FIG. 6.

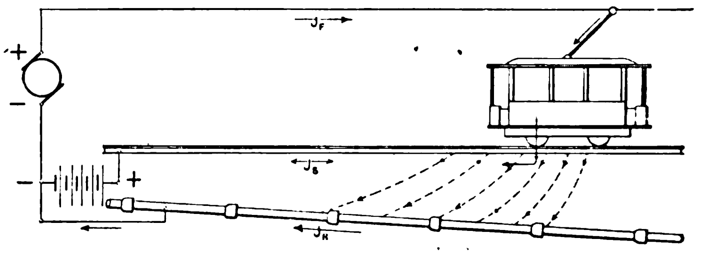


FIG. 7.

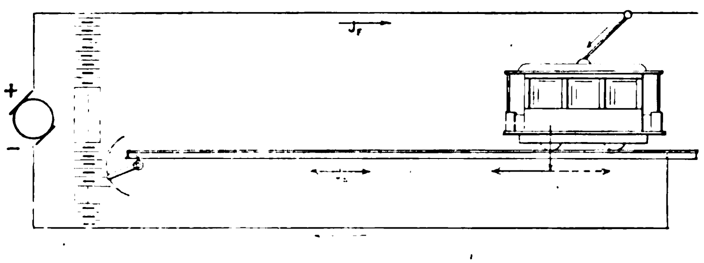


FIG. 8.

Another method is to use the rails as the neutral conductor of a three-wire system; this method is very practical, but cannot be used often; without greater trouble it may be applied only on lines which have double track throughout. The real three-wire system requires two equally loaded halves, if the current in the neutral wire has to be zero. But it is possible to use also unequal loads, if to the existing tramway line, as the one half of the system, another line is added as the other half, containing only an e.m.f. and a conductor. Instead of using different e.m.fs. for both halves of the system, only one dynamo may be used, and the e.m.fs. may be divided by means of accumulator battery, connected in parallel with the dynamo. The general scheme is illustrated in the diagram, Fig. 8, where the end of the rails next to the station is provided with a switch for connecting with different points of the battery.

A modification of this method has, however, been successfully used in practice; the e.m.f. in the auxiliary circuit is given by a booster. The first cost of this system is higher than that of the other method, just described, but it can be used also where the station has no battery, and it has besides the advantage of an automatic regulation. For, if the current in the feeders of the trolley wire is used for the excitation of the booster, it can be easily arranged so that the rails have the least possible current for any load in the line. This system, which is illustrated in Fig. 9, is regarded as being the best for the prevention of electrolysis, assuming good joint between the rails. This method has been in successful use for some time in Great Britain on the tramway lines of Bristol and Dublin and in Germany on a suburban line near Berlin.

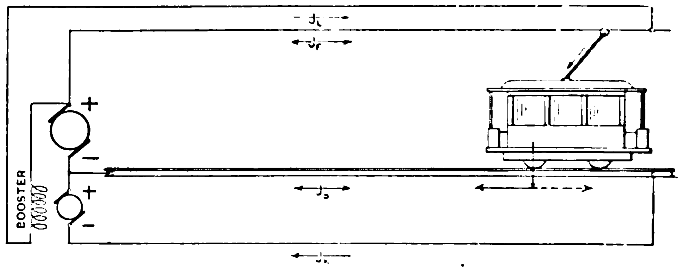


FIG. 9.

Electrical Conductors and Dirt.—It is not unusual to find ceiling wires in open wiring selectively darkened by dust. In a recent issue of the London "Electrician" Mr. A. A. Campbell Swinton gives an explanation of this phenomenon and describes some interesting observations which he has made with five plain pendant fittings, consisting of plain flexible cords leading from ceiling rosettes on the wall. The supply is 200 volts direct current. Three of the pendants are controlled by one switch and the two others by another switch. All the lights are used at once, so that in this respect the conditions are the same in each case. He observed that the three flexible cord connected with one switch remained clean, while the two cords on the other switch rapidly accumulated dust; although they were repeatedly dusted, the effect always repeated itself; the ceiling immediately above the set of two cords was blackened also. The simple explanation which he gives is that the phenomenon is one of feeble electrostatic attraction. In the case of the set of three pendants the switch was in the positive leg of the circuit and the switch in the case of the other set in the negative pole. He found by a voltmeter test that from the negative conductor there were only about 30 volts to earth, while from the positive there were 170 volts to earth. Therefore in the case of the three cords, with the switch in the positive leg, it was only when the switch was turned on a few hours a day that there was any appreciable difference of potential between the cord and the surroundings; and even then only one conductor in the cord had this potential, and the exterior of the covering very possibly always retained zero potential. In the case of the other set of two cords, the switch being in the negative leg, the conditions were similar as long as the switch was turned on. During the many hours, however, every day when the switch was turned off, both conductors remained constantly at a potential 170 volts above that of its vicinity; the dust was therefore caused to deposit upon the cord and upon the ceiling rose by electrostatic attraction. He concludes that in places with an atmosphere like London switches should always be placed in the positive conductor in order to keep them clean, as he claims that it is always the negative conductor which tends to earth itself, a statement which may be questioned. On the other hand, he says that in a damp atmosphere there is an advantage in putting the switch in the negative, for the reason that otherwise the metallic mechanism of the switch is liable to be corroded by electrolytic action.

The Storage Battery in a Traction Plant.—The use of a storage battery in an electric traction plant is now established practice, but the way in which it is used in Southampton, England, is somewhat novel. A description of the plant appeared in a recent issue of the London "Electrician." Southampton has had an electric lighting plant since 1891, which recently came under the control of the municipal authorities, who decided to buy the horse-car lines from the company which owned them, to operate them electrically and to add the railway load to the lighting load, with a view to utilizing the generating plant in the day time. No additional generating plant is to be provided, and all the existing plant is to be used, alternately for the railway and for the ordinary lighting service; an accumulator battery of sufficient capacity to run the entire tramway system for a considerable time every day is to be provided, and forms an important part of the method of working. During the day it is intended to run pairs of the ordinary 230-volt lighting dynamos in series, in conjunction with the booster on the railway feeders, and with the battery across the 500-volt railway circuit. Other machines, running at 230 volts, will supply the three-wire network for the ordinary supply. When darkness comes on, the demand for lighting current will be so large that all the dynamos in the station will be required for lighting alone, so that during the peak of the load the railway system will be supplied entirely from the battery, the erection of which is being rapidly pushed forward. The London "Electrician" remarks on this scheme: "It will be a novel and striking experiment to run the entire tramways of a town so large as Southampton, upon secondary cells alone, and the result will be awaited with something akin to impatience by all who are interested in the development of the secondary battery in connection with traction. Nor will the experiment of running 230-volt shunt machines in series, and boosting up to 500 volts for the tramway service, be without its special interest."

Automobile Motor.—In a recent issue of the London "Electrical Review" there is an interesting description of a new English type of electric automobile. It has two small electric motors weighing only 112 lbs. and driving the two back wheels of the carriage by ordinary bicycle chains, acting directly from a small sprocket pinion on the motor shaft to a larger sprocket wheel fixed to the spokes of the carriage wheel; these chains are adjustable, as in bicycle practice. The motors are mounted on an independent and spring-hung framework, and as each drives separately there is no necessity for balance gear. Two sets of batteries drive the motors and are placed one set under the front seat and one under the back seat. The motors are rated at 2 h.p. each and can develop 3 h.p.; they work at 40 volts. The armatures are external to the field magnets and act as fly wheels; the field magnets have 12 poles. The winding of the armature is of the ordinary "barrel" type turned inside out. Short pieces of square insulated copper wire, all of equal length and resistance, are passed through holes in the iron core of the armature; they are then bent obliquely and connected at the ends to form a wave winding, crossing the armature as many times in one complete coil as there are poles on the field magnets. When completed, they form symmetrical flanges round the sides of the armature, with an equal resistance in each coil, and give little or no windage when revolving. The armature is said to be able to bear an overload of 100 per cent. An axle carrying both the armature and field magnet is fixed at the front and back in a cradle frame of peculiar shape; the armature revolves on one long bearing, and the magnet is fixed to the axle. The motors are completely encased when in use.

A New Method of Forming Plante Plates.—In order to produce the active material directly from the solid lead core, the old process of Plante has long been used; this process gives a layer of peroxide of lead of sufficient thickness in about two months. To avoid the long period of formation, a great number of processes for quick formation have been developed, the plan being not to use pure sulphuric acid or sulphate as the electrolyte during formation, but to add a substance to the solution which acts upon the lead anode rapidly when a current is flowing. For example, by the addition of a very small quantity of chlorine this action is so rapid that after a relatively short period of formation the whole plate is covered with a thick layer of peroxide of lead. But it was found that in plates prepared by any of these quick formation processes, the formation of peroxide of lead from the metallic lead of the core was not completed after the plate had been taken out of the formation electrolyte and placed into the accumulator; the formation continued here and the lead core was destroyed after a comparatively short time. To prevent this, the experiment was made of sending a reverse current through the formed peroxide of lead plate in the forming electrolyte, so that the peroxide was changed entirely into metallic lead; the object being to remove any remaining traces of chlorine, etc., from the plate. It was found in practice, however, that even then small quantities must remain, as the plates were destroyed in a relatively short time. In a recent issue of the "Centralblatt fuer Accumulatoren und Elementenkunde," Dr. H. Beckmann describes a new method which is claimed to overcome this disadvantage of the former quick formation processes. The feature of his method is that he uses an entirely different electrolyte for the process of formation. He puts metallic lead as the positive electrode into an aqueous solution of free sulphurous acid. This solution may be prepared either by conducting free dioxide of sulphur into water, or by dissolving in water a salt which develops dioxide of sulphur with an acid, and by adding acid. When the current is switched on a good layer of peroxide of lead is produced on the positive electrode immediately. Waiting some time before switching the current on, so that the sulphurous acid could be oxidized into sulphuric acid, or could escape, he found it impossible to produce a layer of peroxide of lead, which proves that the sulphurous acid alone causes the formation of peroxide. The principal advantage of this method is that no substances are used which are detrimental to the plate. It is therefore not necessary to send a reverse current through the plate after formation or to remove any remaining traces of the forming liquid; during the process of forming all of the dioxide of sulphur is converted into sulphuric acid, the working electrolyte of the accumulator. Dr. Beckmann says that he has made a long series of tests in which the process proved successful; the formation by this method is completed in 23 to 24 hours.

Some Recent Electrical Patents.

Fool Patents.—It is surprising what ridiculously foolish machines the United States Patent Office will grant claims upon, considering that one of the requirements of patent law is that the device patented must be operative. A much larger number of so-called inventors than would appear from the published records of the office undoubtedly apply for patents in entire ignorance of the state of the art in which their supposed inventions may be classed. Many of these inventors are made aware of the error of their ways by conscientious patent attorneys or by the action of the office itself. Some descriptions of absolutely inoperative devices, however, showing total ignorance of the principles of the art involved, do get through into the condition of patents issued. An example of this is an induction motor patented by G. S. Neeley of Pacific, Mo. The purpose of this induction motor is to operate an automatic voltage regulator for an alternating-current machine, the motor being intended to rotate a centrifugal governor, the vertical rise and fall of the ball of which move the field rheostat arm. The inventor takes for granted that the speed of the induction motor will be proportional to the voltage, a condition which might be approximately attained with an induction motor of proper design, which that described in the patents most certainly is not. Vertical and horizontal sections of the motor are indicated in the accompanying illustration, Fig. 1. The machine is single-phase and the exciting coil, 46, is concentric with the vertical shaft. Around this exciting coil are laid up groups of laminated strips, 45, forming a closed magnetic circuit around the coil. Inside of the drum made up of these strips of iron and separate from it by a wide air gap, is what is intended to act as the short-circuited rotating secondary. This consists of a thin, hollow, cylindrical casting, 17, on the outside and pressing against which is a ring of short-circuited round bars, 22, with no iron between them, but pressed closely in contact with each other. The whole is carefully mounted on elaborate ball bearings with lubricating wells, etc., described at great length in the specifications, so as to reduce friction; whereas, the only way to make the speed of an induction motor respond to changes of voltage in the generator is to make the load considerable and the secondary resistance quite high. Even in this case the speed is affected more by slight variations of engine speed than by changes of voltage. In any event, the motor patented is absolutely inoperative as any lines of force set up by the exciting coil would lie in planes parallel to the shaft and to the bars of the secondary and would set up no torque whatever. To provide a means of adjusting the voltage, the stationary primary coils and core are made adjustable vertically along the shaft so as to embrace more or less of the secondary. The effect of such an adjustment on an operative induction motor can be better imagined than described. Patents No. 646,308 and No. 646,309.

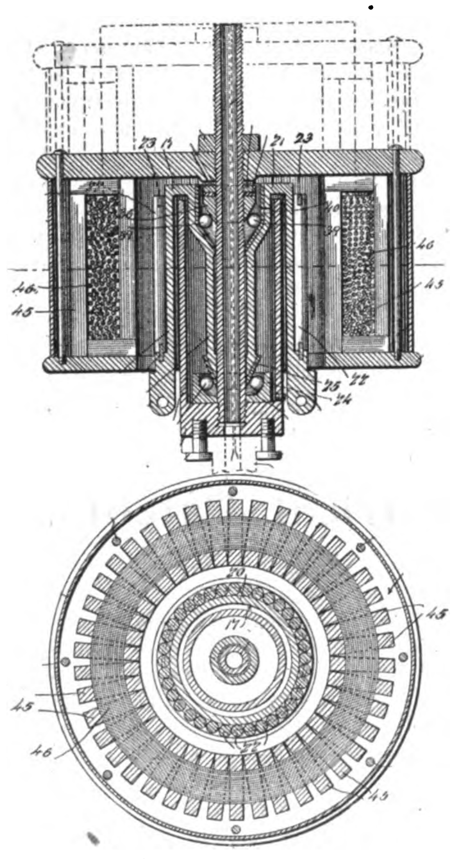


FIG 1.- INDUCTION MOTOR.

Balances for Three-Wire Systems.— While it is customary in this country to use separate generators for the positive and negative sides of a three-wire system, it is often preferable to generate all the current in one or more 230-volt machines, and balance any discrepancies between the two loads on the positive and negative sides by means of small motor-dynamos. The simplest form of balancer of this type is two similar machines, mechanically coupled to each other, their armatures being connected in series across the positive and negative lines, the neutral being taken out from the middle connection between the two armatures. If one side of the system is more heavily loaded than the other, one of these machines acts as a motor, driving the other as a generator, transferring power from the lightly-loaded side to the heavily-loaded side until the balance is restored. In this case the voltage will drop slightly on the heavily-loaded side, due to the ohmic resistance of the armatures of the balancing machines and to other causes. It is preferable to have the voltage at the station rise slightly on the heavily-loaded side and fall slightly on the lightly-loaded side in order to compensate for the neutral drop and for the greater drop in the feeders on the heavily-loaded side and the smaller drop in the feeders on the lightly-loaded side. Several arrangements have in the past been proposed to accomplish this, but one of the simplest and most effective is that recently patented by Mr. W. L. R. Emmet, of the General Electric Company. The arrangement is shown in the diagram of circuits, Fig. 2, where A is the main 230-volt generator, in this case shown compound-wound, supplying the bus bars, a and b. The balancing motor-generator consists of two armatures, B and B′, indicated belted to each other, connected in series across the lines. These machines have shunt fields connected in series with each other through the rheostat, R, across the lines. They also have series fields, F and F, taking, respectively, the total outputs of the positive and negative feeders, these series coils being indicated as shunted by the usual German silver strips, S and S. If with this arrangement the positive side of the system becomes more heavily loaded than the negative, the series coil of the positive machine, B, gets a greater current than that of the negative machine, B′, exciting the field magnet of B to a greater strength than that of B′. Since the two are coupled together and running at the same speed, B must generate a higher counter e.m.f. than B′, thus dividing the voltage between the outer conductors unequally between the two machines. To assume a concrete case, let us say that the field strength of B becomes about 10 per cent higher than that of B′, then the 230 volts between the bus bars will be divided by the two machines in the proportion of about 120 volts for B and 110 volts for B′, if no currents flow through the armatures. Half of the unbalanced current coming back through the neutral G must, however, flow through machine B′, generating the same amount of current in machine B, which compensates for the other half of the current through the neutral. The ohmic drop in the two armatures will take up part of the 10 volts difference between the two counter e.m.fs., leaving the balance to make up for the ohmic drop in the neutral and the increased ohmic drop in the positive feeder over and above that in the negative feeder, thus giving a close balance of voltage at the center of distribution. Patent No. 648,489.

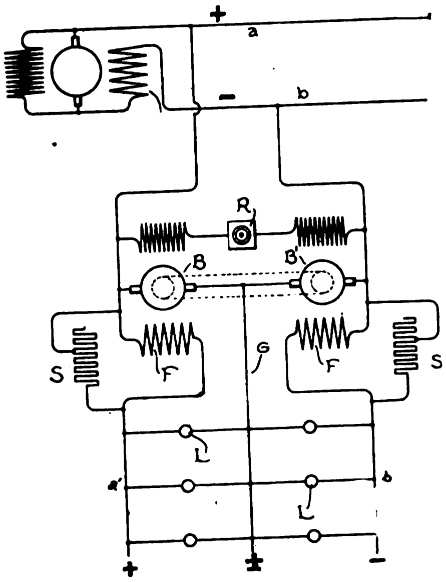


FIG. 2.—MOTOR BALANCER.

An Improved Lightning Arrester.— In the railway type of lightning arrester made by the Westinghouse Company the charred strip of lignum vitae which serves as a guiding path of the lightning discharge has its resistance so lowered by repeated discharges that in some instances sufficient leakage ensues to cause a burn-out and short-circuit. Mr. A. J. Wurts has patented a means of dividing the lightning discharge between several parallel paths, thus reducing the volume and heat generated per path to such an extent that the charred wood is not materially affected. The patent specifications state that it has been found that when several spark gaps of this kind are placed in parallel with each other, the discharge, instead of dividing among the several gaps, will almost invariably pass at one

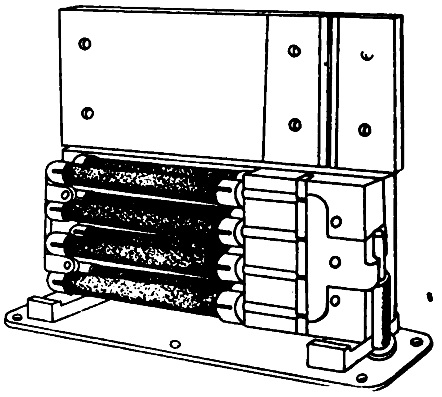


FIG. 3.—LIGHTNING ARRESTER.

gap only, but if a resistance be used in each path, all of the resistances being substantially equal, the discharge will invariably subdivide. For this reason a resistance rod is inserted in series with each discharge gap, several rods and discharge gaps being placed in parallel with each other. Fig. 3 shows a view of a lightning arrester having eight gaps and eight rods connected up in this way. It has been found that a desirable material for the resistance rods consists of a mixture of graphite and kaolin and some binding material, such as starch. These are better adapted for the purpose if unbaked and simply allowed to dry at ordinary temperatures. Under such circumstances, however, the rods are fragile and must be enclosed in a stiffening sheath, generally made of paper wound on to the rod with shellac. Patent No. 649,388.

Shunted Hot Wire Ammeters.

To the Editors, American Electrician;

Sirs:—In the article in your April issue by Mr. E. A. Wagner on "The Use of Hot Wire Shunt Instruments as Alternating Ammeters," Mr. Wagner assumes a suppositious case, in which the meter has no self-induction, and then proceeds to show that under certain conditions the self-induction of the shunt would make the instrument read 10 per cent high, if it were calibrated on direct current and used on alternating current. This would be all right if such conditions were obtainable, but, as a matter of fact, the hot wire in the meter is as much a part of the circuit as the shunt, and as such has as much reactance as any other part of the circuit having the same length, current density and relation to other current-carrying conductors. Uusually, the current density in the hot wire is much higher than that in the shunt (in order to get a large expansion range), but due care should be taken to introduce the current to the hot wire in such a way that the length is proportionately less, so that the ratio of the reactance and resistance of the meter remains approximately the same as the ratio of the reactance and resistance of the shunt.

In the Stanley hot wire instruments this has been accomplished to such a degree that in over one thousand instruments calibrated on direct current and checked on alternating current of any frequency, I have never found one in which these calibrations differed, when the leads connecting the instruments and shunts were of the standard lengths.

In regard to the ratio of the reactance to the resistance in the instrument being greater than that in the shunt, and thus making the instrument read low: this trouble is also eliminated by careful design. Any error introduced by cables of a reasonable length is not observable usually as the ohmic resistance of the meter is relatively high, so that the ratio of reactance of twisted cables to the resistance of the meter is small; thus the error introduced is so small as not to be observable. If, however, the cables are very long, then the error may become noticeable, but never, I think, to such an extent as 10 per cent or anything like it. The worst case that has ever come under my notice was an instrument for 3000 amperes with leads 155 feet long. In this instrument the difference between the reading on direct current and alternating current of 133 cycles was 2 per cent. The leads were made of heavy insulated cable, and the total error, as near as could be calculated, was introduced by the self-induction of the leads; they could not be twisted close enough together.

W. J. Lloyd.

Pittsfield, Mass.

NEW BOOK.

Standard Polyphase Apparatus and Systems (2d Edition). By Maurice A. Oudin. New York: D. Van Nostrand Company. Cloth, 5 x 7½ ins.; 253 pages; 159 illustrations. Price, $3.

This edition of Mr. Oudin's book is a decided improvement upon the first edition, but there remain several errors, either clerical or typographical, which should have received attention in the revision. One of the worst, so far as the effect on amateurs or beginners is concerned, is the statement on page 6 that inductive e.m.f. is 2nLI, instead of $2\pi nLI$. The book contains a concise exposition of alternating-current principles in as simple a fashion as the subject will allow; descriptions of American polyphase generators, motors, rotary converters and transformers; switchboard and circuit diagrams; characteristic curves, and a chapter on the calculation of transmission lines. The table of line constants in this last-named chapter is evidently calculated for wires strung 18 ins. apart, although no information is given on this point. The book is written throughout in plain language to meet the needs of practical workers, for which it is excellently qualified.

NOTES.

A Pleasant Automobile Run.—The Automobile Club of America took a run from New York to Philadelphia on June 2d, returning on June 4th. The club started from the Waldorf-Astoria Hotel at 7.30 a. m. Eight vehicles driven by steam, nine driven by gasolene, and three electric vehicles participated in the run; one of the electric carriages was the Riker machine, which made a name for itself by distancing other competitors in the recent 50-mile race on Long Island.

First Three-Phase Railway in Germany.—The first railway to employ three-phase motors in Germany was recently completed between Murrau and Oberammergau, a distance of about 15 miles. The central station is located at Kammerl, about 10½ miles from Morrau, and contains three three-phase generators driven by turbines of 500 horse-power each. The water is led to the wheels through a canal about a mile long and iron pipes about 230 feet long. In addition to the electrical equipment, the road is provided with an auxiliary equipment in the shape of steam locomotives to take care of the excessive crowds which visit Oberammergau every ten years at the time of the Passion play.

New York Electrical Society.— At the annual meeting of the New York Electrical Society, held June 14th, Mr. E. W. Caldwell read a paper on "Recent Advances in Rhumkorff Coil Interrupters," and Mr. Gano S. Dunn gave an interesting description of some work which he did several years ago in tempering steel wheels electrically. Mr. Dunn, in the course of his remarks, gave a demonstration with an enormous Wehnelt interrupter, the effects from which were so powerful that the observers were burned exactly as though by the sun; the skin subsequently peeling from their faces.

The Northwestern Electrical Association.—The summer convention of the North-western Electrical Association was held at Chain of Lakes, Waupaca, Wis., June 26th to 28th inclusive. The programme included papers on "Wet Steam," by W. H. Edgar; "Advantages of Recording Wattmeters on Switchboards," by W. Worth Beam; "Storage Batteries for Small Central Stations," by Louis A. Ferguson; and one on "Street Lighting," by H. H. Wait. Following the daily sessions of the convention the delegates were well entertained by excursions on the lakes, Olympian games, minstrel performances, tub races, swimming matches and other diversions.

A Freak of Lightning.—A lightning discharge recently entered the high-tension generating station of an electric railroad system in the southwest using polyphase distribution, and set up effects which it is extremely difficult to explain. The discharge filled the station with smoke and brought the 1200-h.p. engine up standing. When started up again it was found that no great harm had been done, the insulation of the 11,000-volt lines and armature coils of the generator being intact. The only apparent effect of the shock was an open circuit in the field rheostat of the exciter. With a jumper around this open section of the rheostat the machines ran as well as before the storm. An investigation back of the board showed that the discharge had jumped from one high potential terminal of the voltmeter transformer to a lead running from the exciter to the field of the main generator. From this connection it evidently found its way to the exciter field rheostat, about the last point where one would expect to find the effects of a lightning discharge entering over high-tension lines. That such a discharge could bring a powerful engine up short against full steam pressure without setting up such electrical strains as to destroy some parts of the circuits is equally mysterious.

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Piping in Central Stations.

There are few classes of service the provision for which demands so much care in the arrangement of steam piping as in the case of an electric central station, for either lighting or railway supply or both. The one absolutely indispensable condition obviously, is continuity of operation. In industrial establishments of the general manufacturing type a shut-down is naturally regarded as a thing to be guarded against, but it is rarely the case, even in the most important of this class of factories, that a shut-down of an hour or so works any serious harm beyond the diminution in production. The condition in even the most insignificant central station is in conspicuous contrast to this, as all who have had any connection whatever with central-station work have learned more or less painfully. The insurance of continuous service involves, of course, not only reliability in the actual generating apparatus, but reliability of connection between the boilers and engines.

The natural tendency of steam fitters after first learning the lesson of operative reliability was to duplicate piping, but, as pointed out by Mr. Ennis on another page, the cumbersome complication and expense entailed inevitably led to the supercession of duplicate pipes by better material and more careful design and workmanship. The importance of the use of only the best grade of pipe and fittings, properly laid out, cannot be too forcibly emphasized. Such admonition is superfluous to the designer of a large plant; it is relevant only to superintendents and engineers of plants of small or moderate size. It is too often the case that because of the small size of an installation anything is considered sufficient in the way of piping. As a matter of fact, no central-station plant has ever been built so small as to justify the use of cheap fittings and light-weight pipe, or the employment of "jerry" methods in laying out and erecting the piping system. There are, to our knowledge, some plants in which the piping is innocent of such "theoretical" refinements as expansion bends, drips and insulating covering, and over which a kind Providence seems to have exercised the beneficent care traditionally accorded to fools and inebriates. These remarkable exemptions have doubtless been taken as shining examples time and time again by penurious prospective owners, and it is some satisfaction to reflect that the great majority of these must have suffered a deservedly rude disillusionment after putting their fatuitous and parsimonious ideas into practice.

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The National Electric Light Convention.

The annual convention of the National Electric Light Association, held recently, was in the main very satisfying in the matter of papers and discussions. Most of the former were timely and beneficial, and the latter were vigorous and eminently instructive.

One of the soundest arguments advanced for the guidance and welfare of central-station men was contained in Mr. Cahoon's paper on "Uniform Accounting," namely, that in order to guard against municipal ownership it behooves central stations to puncture the bubble of popular hallucination concerning contract profits by making public the actual figures relating to operation. Even where municipal ownership was not threatened, there have been many cases in which lighting contracts have been lost and franchises either annulled or rendered valueless by reason of inflated ideas as to the profits available which have aroused the cupidity of ignorant capitalists, who proceeded to underbid for the contract. It is small consolation to the disfranchised company in such a case to know that financial disaster inevitably awaits its reckless successor.

The discussion of arc lamps for street lighting was unusually full, and the point was brought out by several of the speakers that effective illumination is far more important than photometric tests for mean hemispherical candle-power. This is not new information, of course, and it seems rather odd that so much reiteration should be necessary in order to bring the fraternity to a realization of what is such an obvious fact. Five years ago Dr. Kennelly brought out the selfsame point in a paper read before the Cleveland convention, and it has been resurrected more or less emphatically at intervals ever since that convention.

The trend of arc-lighting practice appears to be strongly toward enclosed alternating-current arcs; in fact, in the existing state of the art, there seem to be very few conditions under which the use of the open arc is at all advisable. Probably the chief commercial reason for this is the longer life of the carbons, permitting as it does less frequent trimming and a consequent increase in the number of lamps to which one man can attend. So far as the general service is concerned, however, the principal advantage possessed by the enclosed arc is superior light distribution, due partly to the greater distance between the carbons, but more to the diffusive effect of the envelope.

A step farther in the direction of uniformity of illumination is afforded by the craterless alternating-current arc, which accounts for the preference accorded to it over the direct-current arc; and the *desideratum* of evenly distributed light is still nearer approximated by the use of opalescent globes, which are usually preferable even for street lighting service, despite their inefficiency when considered purely as light transmitters.

Of course alternating-current arc lamps are afflicted with a power factor which may be anywhere from .50 to .90, according to the type of lamp and character of circuit, and they are not so easy of construction as direct-current lamps of equal mechanical efficiency. But the demand for fair distribution of light between the lamps, in contradistinction to intense light beneath each and little or none midway, has grown to be paramount, notwithstanding the mental lethargy as to the subject which exists in some quarters

Reactance and Skin Effect in Wires.

Beginners in the study of electrical phenomena find it extremely difficult to grasp the fundamental principles of alternating currents even with the assistance of accurate and clearly-phrased text books; when they are hampered and misled by the sort of misinformation which is industriously dealt out by some of the class publications they are indeed subjects for commiseration. The efforts of non-electrical engineering papers to supply their readers with elementary electrical information are highly commendable —far be it from us to advert upon such efforts when proper precautions are taken as to the soundness of the information. The only and serious cause for criticism lies in the slipshod character of the didactic matter, which really appears in most cases to be collated unintelligently and is almost always garbled.

One of the latest specimens of this kind is the statement that "in wiring calculations there is but little difference between the drops on alternating-current and direct-current work (*sic*) except when the wire becomes large. The skin effect then is quite considerable and the increased drop must be allowed for. This can readily be obtained from tables." Those who are familiar with the subject will dismiss this distortion with a smile, but the hundreds of seekers after electrical knowledge who have no source of enlightenment other than the two or three papers for which they manage to subscribe will be hopelessly confused by it.

What the author of the above sciolism probably had in mind is reactance, which is, of course, totally different from "skin effect." The latter is negligible under usual conditions of practice for the reason that it attains significance only at very high frequencies and in very large wires. At the maximum frequency ever used in this country (140 cycles) no trouble is experienced from "skin effect" until the size of the wire exceeds the standard gage limit, and in plants of such magnitude as to require the use of extraordinarily large conductors, the frequency is seldom over 60 cycles. Even at 133 cycles the "skin effect" in a conductor one-half inch in diameter increases the resistance effect of the wire about 2½ per cent, and when two wires each of one-half the cross-section are substituted for the single half-inch conductor, the "skin effect" drops below 1/100 of one per cent. At 60 cycles this effect is almost always negligible. The reactance of an alternating-current line, on the contrary, is by no means negligible when the wires of a 60-cycle circuit are larger than No. 6 B. & S. gage, or those of a 133-cycle circuit are larger than No. 9. Moreover, the power factor of the load has a most important influence upon the effective drop in the line, with a given current flowing. Again, the distance apart of the wires affects the reactance seriously, the inductive effect being directly proportional to 0.10857 + log r, in which expression r represents the ratio of the distance from center to center of two parallel wires to the radius of one of them. It is evident from this expression that the inductive effect increases slowly with the distance between the wires, and decreases in the same ratio with an increase of diameter.

In view of this fact it may seem paradoxical that reactance should need to be reckoned with in large wires and not in small ones. The explanation of this is that the resistance of wires increases much more rapidly than the reactance, as the size diminishes, so that in large sizes the reactance constitutes a much larger part of the total impedance than in small ones. For example, two parallel wires strung nine inches apart, if of No. 0 gage, will have a reactance equal to their resistance, at 60 cycles; if of No. 10 gage, the resistance will be practically eight times as great as the reactance. As the reactance effect is at right angles with the resistance effect, the apparent increase in resistance cannot exceed three-quarters of one per cent with the heaviest load the wire could carry, and ordinarily the increase would not exceed one-tenth of one per cent; both figures are evidently negligible.

However, definite comparisons cannot be drawn which will apply to all cases. The power factor of the load; the resistance drop in percentage of the delivered e.m.f.; the frequency, and the distance apart of the wires are all controlling influences, so that if the writer quoted in the second foregoing paragraph referred to reactance his statement is incomplete and worthless, besides being misleading by reason of the use of the term "skin effect;" if the latter was really meant, then the statement is extravagant and superfluous.

The Fashion in Field Magnets.

It is frequently amusing and interesting to note the effect of "precept and example" upon engineering design. A case in point is that of dynamo and motor field magnets. Early in the art, the Edison bipolar type prevailed; then Mr. Weston departed to the horizontal consequent-pole type, and most of the other designers followed sheep-fashion. Then somebody introduced the Lahmeyer or Continental type, and the trailing process was repeated, but not as generally. The circular yoke with radial magnet poles, is the latest "'fashion," and as this type combines more advantages than almost any other, it has reigned much longer than previous designs. Even this form of magnet has been subjected to modifications which have been promptly and freely copied immediately upon appearance. A notable instance is the ungraceful but really utilitarian "barrel type," resembling a covered garbage can laid down on the side. This type, however, as someone once said regarding sauerkraut, is "much better than it looks." As the gamut of practical magnet shapes has been about run, it is safe to conclude that the circular yoke and radial poles will remain.

DESIGN FOR A SIMPLE TRANSFORMER IN FOUR SIZES.

BY CECIL P. POOLE.

The transformers here described can be built by any amateur without the use of machine tools; some form of winding machine being the most important piece of constructive apparatus. In order to eliminate the bugbear of stampings, the core is made of an unusual type, involving the use of simple rectangular strips of transformer sheet iron, No. 27 gauge, all of one size. The coils surround the core exactly like the windings of an induction coil, and the core sheets are bent back around the outside of the coils and lapped, as indicated in Fig. 1, which is a horizontal section through the center of the transformer, with most of the core sheets omitted beyond the ends of the winding. All four sizes for which data are given are of identical construction, the only difference being dimensional.

The first step is to make two wooden core blocks, like Fig. 2; one on which to mount the primary bobbin and one for the secondary bobbin. One head may be put on permanently, but the other must be removable. The dimensions are given in Table I. A spindle of ¾-in. round iron should be put through the center of the core lengthwise, and if a lathe is not available for winding purposes, one end of the spindle may be bent into a crank and the whole structure mounted between two simple upright posts, to form a winding machine.

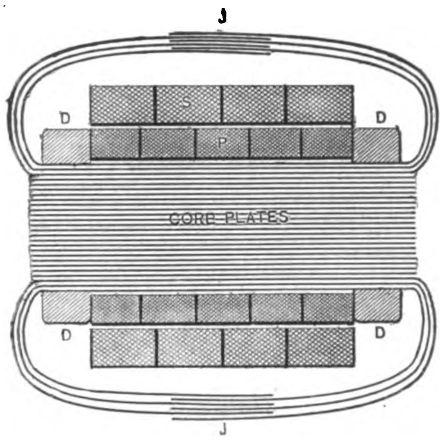

FIG. 1.—SECTIONAL PLAN.

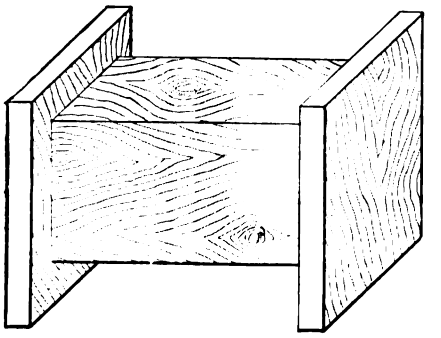

FIG. 2.—WINDING CORE BLOCK.

The next step is to make the retaining bobbin for the primary winding. Take a sheet of heavy fuller board, of the size specified in the table of dimensions, and cut four slits in each long edge, as shown in Fig. 3 at a and b; these slits are ¼ in. long in all cases. Bend the sheet into the shape shown by Fig. 4, forming a sort of box with open ends, and slip over the outside six rectangular collars of vulcanized fiber, like Fig. 5; these are 1/16 in. thick. Bend the flaps, c, Fig. 4, outwardly at right angles with the wall of the "box," so that when the collars are finally adjusted into place along the outside, each end one will be held on by four flaps, as indicated in Fig. 6. The surfaces of the flaps may be coated with thick shellac varnish in order to keep them in place against the faces of the end collars.

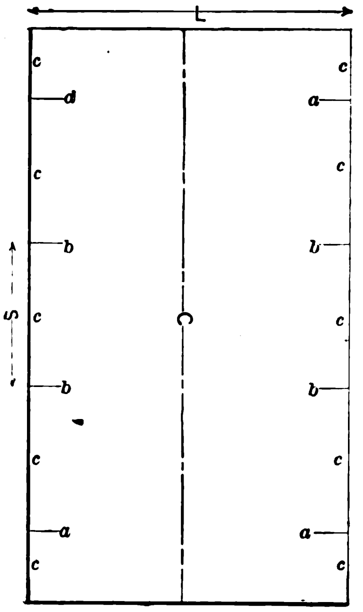

FIG. 3.—BOBBIN CORE SHEET.

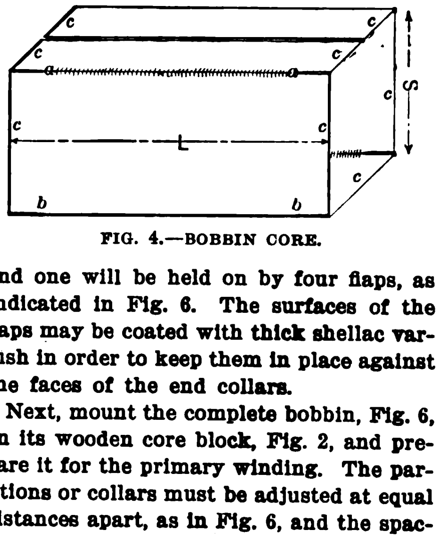

FIG. 4.—BOBBIN CORE.

Next, mount the complete bobbin, Fig. 6, on its wooden core block, Fig. 2, and prepare it for the primary winding. The partitions or collars must be adjusted at equal distances apart, as in Fig. 6, and the spacing maintained temporarily by means of wooden blocks. Before applying the winding, the seam where the edges of the fuller board meet must be covered by a strip of the same material laid clear across the side of the box in each of the compartments and secured in place by varnish. Then the coils may be wound on, care being taken to observe rigidly the prescription of Table II as to number of turns per section. The starting and finishing ends of each coil or section must be of heavier wire than that of the coil itself, and rubber covered with an outer braid; No. 18 wire is a good size for the two smaller sizes of transformer, and No. 14 for the two larger ones.

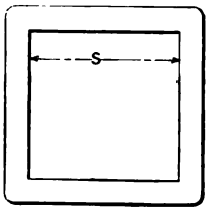

FIG. 5.—COLLAR.

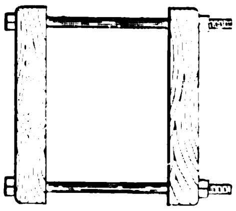

FIG. 9.—JOINT CLAMP.

After winding and securing the ends with heavy linen thread, tag the ends, marking the inner or starting ends, "B," and the outer or final ends, "F." Then tape each section thoroughly and lead the terminals of the various sections lengthwise along the outside of the whole winding to one end, securing these terminal wires to the surface of the structure by means of a few extra turns of tape. All of the terminals should project from one end of the complete winding, and they should be laid side by side in regular order.

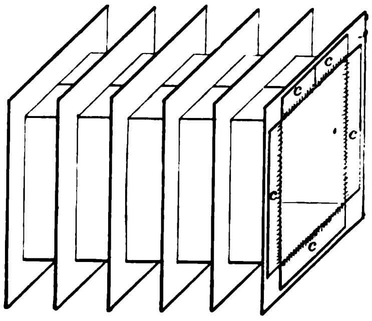

FIG. 6.—COMPLETE BOBBIN.

The secondary bobbin or box is made in exactly the same way as the primary, but has only five collars instead of six, and is larger in size, as Table I shows. After winding the secondary, tape it on the outside and tag the ends, like the primary; varnish both heavily with either P. & B. or shellac, and set them aside to dry.

Next mount between two pairs of wooden dogs the requisite number of core plates to make the proper thickness, as indicated in Figs. 7 and 8, drawing the dogs up snug, and wrap the core plates tightly with three layers of plain linen tape along the portion between the dogs. Varnish the outer layer of tape lightly; remove one pair of dogs, and slip on the primary and secondary windings separately. The windings should be so disposed that the sides

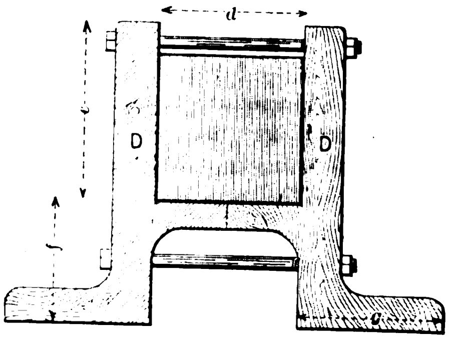

FIG. 7.—CORE-CLAMPING DOGS.

out of which the terminals lead are on top. When the windings are in place, put back the pair of dogs previously removed and bend the core plates around the ends, lapping them as indicated in Fig. 1; one-half of the plates should be carried around one side and one-half around the other. The lapped joints must be tightly clamped together by means of two wooden strips 1⅛ ins. wide and 2 ins. thick, drawn together with ⅜-in. iron bolts, as shown by Fig. 9.

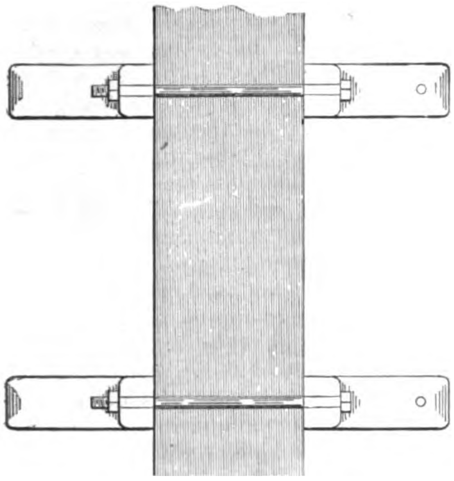

FIG. 8.—CORE-CLAMPING DOGS.

TABLE I.—MECHANICAL DIMENSIONS.

Size of transformer, watts	200	500	750	1000
Length of core plates	20 ins.	22 ins.	30⅛ ins.	31⅛ ins.
Width " "	1¾	2⅛	2¾	3
Thickness of compressed core, d	1¾	2⅛	2¾	3
Primary Bobbin:				
Length of sheet, C	7⅛	10⅛	11⅛	12⅛
Width " L	4⅞	5¼	5 9/16	5⅝
Length of finished bobbin	4⅜	4¾	5 1/16	4⅞
Width of one side, S	1⅞	2⅝	2⅞	3⅛
Depth of flanges	⅝	⅛	⅛	⅛
Secondary Bobbin:				
Length of sheet, C	12⅛	15⅛	16⅛	17⅛
Width " L	4⅞	4¾	5 9/16	5⅝
Length of finished bobbin	4⅜	4¼	5 1/16	4⅞
Width of one side, S	3⅛	3⅞	4⅛	4⅝
Depth of flanges	⅛	⅛	⅛	⅛
Core Dogs, D:				
Depth of core clamp, e	3⅛	4¼	4⅛	4¾
Thickness parallel with the core	1	1	1	1
Thickness parallel with the bolts	1⅛	2	2	2⅛
Height, foot to core, f	1⅛	1⅛	1¾	2
Length of foot, g	2⅛	3	3	3⅛

TABLE II.—ELECTRICAL AND MAGNETIC DATA.
At 1000 volts primary and 100 volts secondary; 133 cycles.

Output of transformer watts	200	500	750	1000
Primary Winding:				
Size of wire, B. & S	No. 26.	No. 22.	No. 20.	No. 19.
Turns per section	610	300	250	220
Total turns	3,200	1,500	1,250	1 100
Depth of winding, layers	20	12	11	11
Resistance, hot	128	30	18	13¼
C²R loss, full load	5⅛	7⅛	10⅛	13¼
Secondary Winding:				
Size of wire, B. & S	No. 16.	No. 11.	No. 10.	No. 9.
Turns per small section	57	27	23	20
" " large "	103	48	40	35
Total secondary turns	320	150	126	110
Number of layers	5	4	3	3
Resistance, hot	2	0 34	0.2	0.175
C²R loss, full load	8	8⅛	11⅜	17⅛
Losses, Full Load:				
C²R, both windings	13⅛	16	21.5	30⅜
Hysteresis	13	8	10.7	8¼
Eddy currents	1⅞	1	0.8	1
Total losses	28	25	33	40
Full load efficiency	88%	95%	95.6%	96%

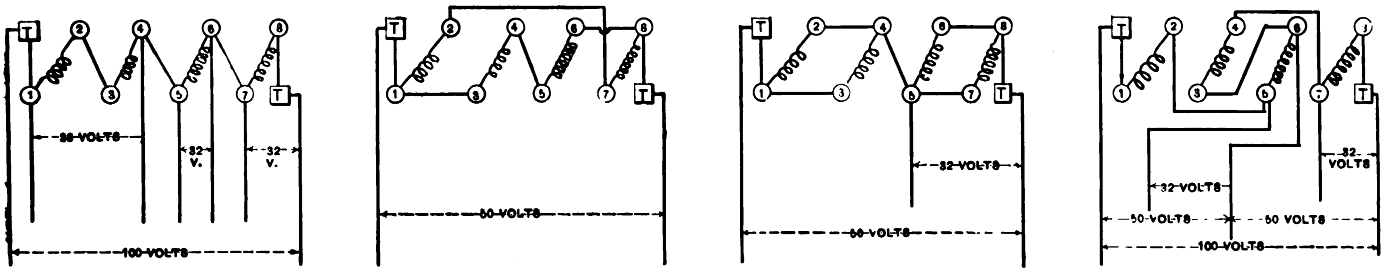

FIG. 11.—FOUR OF THE AVAILABLE COMBINATIONS OF SECONDARY WINDINGS.

To the upper ends of the four dogs which hold the core, screw a tablet board to which the terminals of the windings are led and from which the main transformer connections are made. The tablet board is most easily made of "soapstone slate," which is merely a very soft grade of light gray slate. Wood or fiber will not do and hard rubber would be expensive. On it mount eight single-pole double-throw "baby" knife-blade switches, two primary terminal blocks, eight heavy binding posts and two secondary terminal blocks, as indicated in Fig. 10. The sketch also shows how the coils are connected to the switches and binding posts.

The transformers are all designed for 1000 volts primary e.m.f., with all of the primary coils in series, and 100 volts secondary e.m.f. with all of the secondary coils in series. The primary winding is divided into five equal sections of 200 volts each, so that it can be grouped for 200, 400, 600, 800 or 1000 volts. In grouping for 400 and 800 volts one section must be left open, and in grouping for 600 volts two sections must be left disconnected from the main primary terminals. The original object of the writer in dividing the primary into 200-volt sections was to permit the transformer to be supplied from either an ordinary 1000-volt primary circuit or a 200-volt motor circuit. The reader will readily understand that this arrangement is not compulsory; the primary may be wound in a single coil without any partitions, if desired, although it will be found more reliable if two or three partitions be used to reduce the voltage per section.

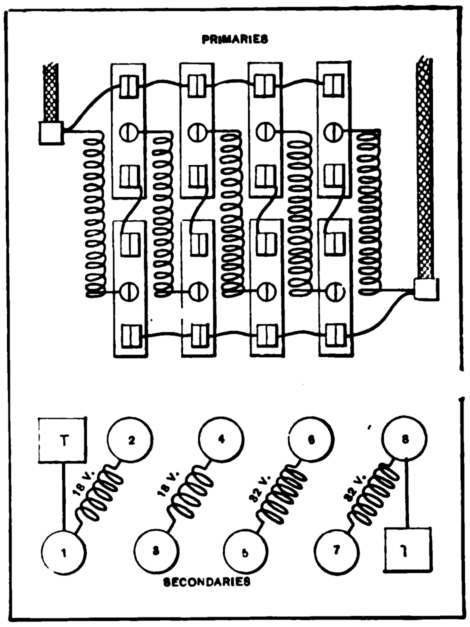

FIG. 10.—TABLET BOARD DIAGRAM.

The secondary winding as designed is divided into two sections of about 18 volts each and two sections of about 32 volts each. No switches are used for making the various combinations because too much space and complication would be required. The connections are to be made between the various binding posts by means of short lengths of heavy iron—No. 6 or No. 8 gauge. In order to avoid excessive ohmic losses the wire should fit the hole in the binding post snugly. All of the binding posts should have two holes and binding screws each.

With the primary switches all thrown inward, the primary sections are in series for 1000 volts between the terminal posts. With all of them thrown outward the primaries are in multiple for 200 volts. Other combinations may be easily traced out. At the secondary end several combinations are obtainable, as shown by Fig. 11; the most serviceable will doubtless be found to be the one on the left of the sketch.

The tablet board must be kept enclosed by a box cover when the transformer is in use. The fuse blocks and master switches should be located at a little distance from the transformer, and the cover should never be removed except when the primary switch is open.

THE IMPORTANCE OF PHOTOMETRY TO CENTRAL STATIONS.

BY LYMAN C. REED.

The success which the electric light has attained is based primarily on its aesthetic qualities, its convenience, cleanliness and adaptability, rendering it superior to any other commercial light, but not necessarily cheaper. Its march forward to the final limit of universal use depends then on two main underlying qualities; first, its superiority over other lights; and second, its ability to compete commercially with other light-giving sources. Almost every day brings forth some new form of light, which the enthusiastic inventor claims will in a very short time render the electric light obsolete. The best answer to such claims is found in the rapid enlargement of the electric central stations in every part of the world.

The price of electricity has shown within the past few years a tendency to become cheaper as more economical methods of generation are utilized, but it is safe to say that no very radical departure in present prices will come about as long as the efficiency of the incandescent lamp remains at its present low figure. The lamp may be considered the keystone of the entire structure; it is the final link in the series of transformations of energy which take place between the coal-pile and the light, and on its economy (other conditions being favorable) depends the earning power of the central station.

The economy of the incandescent lamp must be viewed from two standpoints, that of the consumer and that of the central station. The light emitted from an incandescent lamp filament increases rapidly as the voltage across the lamp rises, and if the voltage is maintained above normal for any length of time, the life of the lamp is very much shortened. The higher the voltage is raised, the greater becomes the efficiency of the lamp; that is, the more light per watt of energy it gives. Viewed from the consumer's standpoint, the lamp should not last more than a few hours for him to get the best returns for his money. This would necessitate such frequent renewals by the central station that the cost of furnishing lamps would be prohibitive.

Viewed from the central station's standpoint, the lamp which lasts the greatest number of hours is the best lamp; that is, it needs fewest renewals, and hence is the most economical. Between the two extremes here presented there must be a mean which should combine the good qualities of both conditions in the greatest possible degree. The perfect lamp would maintain a constant candle-power for an indefinite period with small expenditure of energy; the modern commercial lamp endeavors to give a fairly uniform candle-power for a limited period with an expenditure of energy varying from 3 to 4 watts per candle.

It has been found that the long-life lamp is usually of low efficiency to start with, and this efficiency becomes lower as the number of hours the lamp burns increases, until in many instances the efficiency becomes as low as 10 watts per candle. The amount of energy consumed per candle renders the lamp in this condition uncommercial and destroys its aesthetic qualities. In other words, the consumer agrees to pay for light at the rate of 3 to 4 watts per candle and will not consent to pay at the rate of 10 watts per candle for an inferior light. The central station, then, in order to fulfill its contract with the consumer, must see to it that the amount of light furnished per watt is maintained at somewhere near the required power.

Assuming the average total life of the lamp to be 2000 hours, the power to be 16 candle-power at 3.1 watts per candle at the start, and 8 candle-power at 6 watts per candle at the end of the 2000 hours, the mean candle-power and efficiency over the total period may be roughly taken as 12 candle-power at 4.5 watts per candle; in other words, this might be the candle-power and efficiency at the end of 1000 hours. A new lamp of this quality (12 candle-power at 4.5 watts per candle-power) would be considered uncommercial on a circuit having close voltage regulation; why, then, should it be tolerated simply because it has had the misfortune to burn 1000 hours?

The lamp reaches an uncommercial state at some point previous to this time, and the results of a great number of tests have shown that the commercial period of a high-efficiency lamp is reached in about 600 hours burning. The average 3.1-watt lamp burning at an initial candle-power of 16 has at the expiration of 600 hours a candle-power of 13 and an efficiency of 3.7 watts per candle, which may be considered the end of the commercial life of the lamp. The average efficiency of the whole period is 14.5 candles at 3.38 watts per candle.

In order for a central station to compete successfully with the close competition of Welsbach and other lights, the candle-power of the lamps of the entire service must be maintained in first-class condition. To do this successfully a system of periodic renewals must be instituted, the frequency of which can be roughly estimated from the consumer's bills. If a consumer having 10 lamps develops a gross bill of $10 a month at one cent per lamp-hour, the average service per lamp is 100 hours, and the renewals of lamps need only be made twice a year.

The maintenance of a clean lighting service without any waste in the lamps displaced by renewals necessitates the photometering of all the lamps returned. The lamps in the consumer's premises frequently become fly-specked and covered with dust so that it is impossible to judge of the true candle-power of a lamp until it is cleaned. As the lamps must be changed by cheap labor, it is best not to invest this labor with fancied powers of discrimination, but to have all the lamps in a given installation changed regardless of their appearance.

Some idea of the total cost of renewals in lamps may be gained for any station by proceeding as follows: In a typical plant, assume 1000 16-c.p. lamps connected, and a gross income of $3650 per annum at ¾ cent per lamp-hour. Then the average income per day will be $10, corresponding to 1333 lamp-hours a day, or 1.3 hours per lamp per day. Allowing 600 hours per lamp as the commercial life, each lamp would last 461 days, requiring the renewal of about 800 lamps per year. This figure is somewhat higher than would be met in practice, but it amounts to less than 5 per cent of the gross income. The increased income from good service would more than counterbalance the cost. This policy on the part of a central station would be very popular and could be used effectively in soliciting new business and settling disputed bills, not to mention the inducement it gives the consumer to burn more light.

To return to the photometric features of the work, the renewal of lamps should be carried out daily, and the returned lamps cleaned preparatory to testing. The tested lamps are assorted into two classes, those testing between 13 and 16 candle-power are retained as a sort of second-class stock, and those testing up to 16 candle-power and over are treated specially and considered as first-class stock.

If the first-class stock is in the majority the lamps are tested for this class first, if the second-class stock is the largest the lamps are tested by setting the photometer screen at 13 candle-power and rejecting all under this candle-power. The good lamps left are then tested by setting the screen at 16 candle-power and sifting out the separate classes. By following this order the minimum amount of handling the lamps is encountered.

The second-class stock is preferably used for special illuminations and outdoor work, but if there is not enough demand in this line to balance the supply of such stock, it may be judiciously issued to points near the plant where a higher voltage is maintained. This second-class stock has a short average life. The lamps testing 16 candle-power have their stubs buffed and the glass thoroughly cleaned, any defaced labels are removed and new ones put on, and the lamp is made in every respect to look as good as new. Such stock is issued on equality with new lamps. The cost of photometering is very small; the entire cost of cleaning, photometering and buffing the stubs is about ½ cent per lamp.

In carrying out the system of renewals

the area covered should be divided into districts, and these districts carefully gone over at regular intervals, the work being so arranged that a specified number of lamps are changed each day. Boys are usually employed in this class of work; no special intelligence is required, as the work consists in simply removing the lamp and putting in a new one.

The system of free renewals is no new experiment, its utility has been well established, and when practiced in conjunction with a photometer, as outlined in the foregoing paragraphs, it furnishes an ideal system of maintaining the commercial efficiency of the entire lighting system at its proper value without incurring the slightest loss due to waste by such renewals.

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ELECTRIC CAR FUSES; WHY THEY BLOW.—II.

BY P. E. CHARLES.

As stated in the previous article, one of the commonest and most troublesome sources of fuse-blowing is the wrong connection of the motor fields. Considering the way in which modern motor fields are connected, together with the small amount of room to be found inside of a motor, it is no wonder that a man who does not know anything about the theory of connecting a set of fields should get a coil in wrong. The coils and leads are so compactly laid into the small space available and the leads from different coils are, in so many cases, run side by side and cleated up together, that even a man who knows how the coils ought to be connected cannot tell if they are connected right or not, because he cannot see or feel the leads throughout their length. Motors do not often leave the factory with their fields in wrong, because they are given a running test before they are sent out, and the speed of the machine during the test will be far above its normal value and the brushes will spark badly. These same symptoms hold to some degree after the motors are put under a car. Where most mistakes are made in connecting fields is in replacing a coil which, on account of some fault or other has been taken out; or where a motor on a closed car standing in the house has been robbed to replace faulty fields on an open car that is in service.

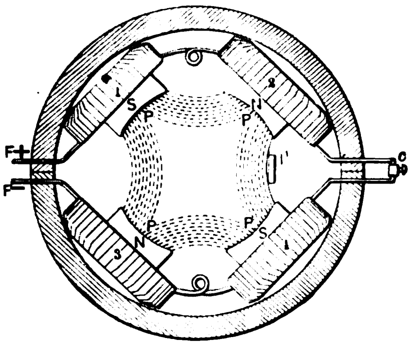


FIG. 2.

It is all well enough to say "connect the new field that you put in the same as the old field that you take out." If the old field is taken out on account of a loose connection or ground or any other fault liable to happen to a perfectly sound car which, up to that time, had given no trouble, all right; but if the car has been run in several times for breaking or blowing fuses there may be some wrong connection in the field, in which case if the coil is put in same as it was taken out it will be still wrong; so this rule cannnot, in all cases, be relied on to secure the correct practice. A motor may have four field coils, and four pole-pieces, as shown in Fig. 2, or it may have two field coils and four pole-pieces as shown in Fig. 3. In either case, the final effect of sending a current through the coils must be to alternate the polarity of the pole-pieces or poles; calling any given pole north the pole on each side of it must be south, and the one across from it must be north, as shown in the two figures. Now, the polarity which any coil will give to its pole-piece depends entirely on the direction in which the current flows around the coil, and this, in turn, depends on which end of the coil the current enters. The trolley wire on a railway circuit is commonly arranged to be the positive side of the circuit, so the current may be assumed to go into a motor field at the end which is electrically nearest the trolley wire and to come out of the end which is electrically nearest the ground. Looking at the face of the pole-piece, if the current flows around the pole clockwise, as shown at S, in Fig. 4, the pole will be a south pole; but if the current flows around the pole counter-clockwise, as shown at N, the pole will be a north pole.

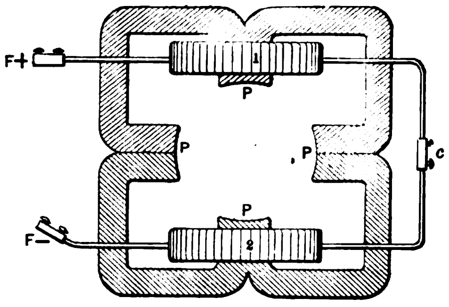


FIG. 3.

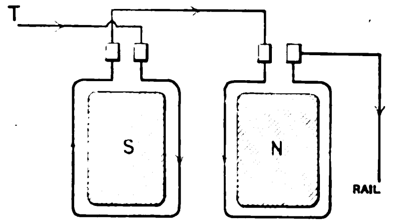
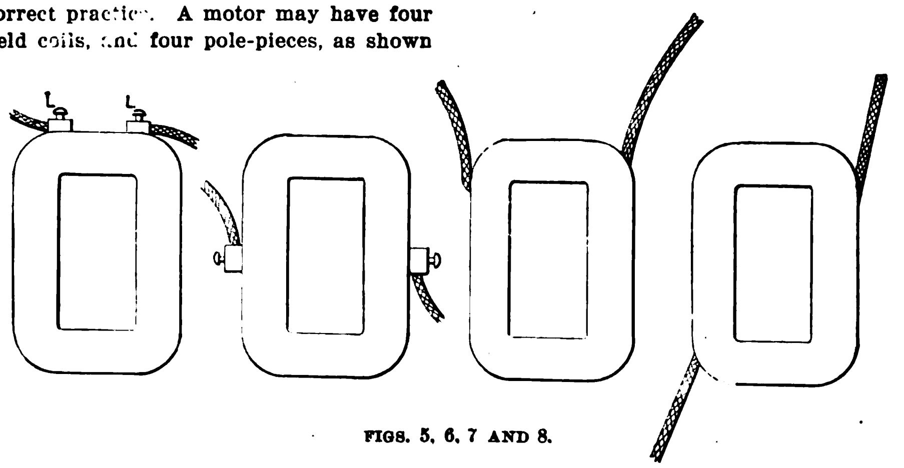


FIG. 4.

Now the average man looking for trouble on a car that is wanted on the road as soon as it is in shape to run, has little or no time to think about whether a coil is carrying current clockwise or counter-clockwise; he wants an easily remembered and commonsense rule to insure getting a coil put in right; he wants a simple test that will decide if one of the coils is in wrong. This being decided, he wants to know how to find out which coil is in wrong when the connections are so obscured that they cannot be followed with the eye. It is not necessary in order to get field coils in right to know in which direction the current will flow around each, but it is necessary to know what amounts to the same thing, namely, in which coils the flow of current ought to be and is in the same direction and in which it is not. Fortunately, from the very nature of the manner in which a coil is made, this is easy to tell on most coils. Every coil has an inside end and an outside end. The inside end leads to the first turn of the first layer of wire put on the coil when it is wound; in order to get at this and to connect it up, it must be brought to the surface of the coil; in its passage to the surface of the coil it must pass every layer of wire in the coil, and in order to insure that it shall not come in contact with any of these layers, it must be well insulated. This thick insulation makes a bump or ridge or raised place on the surface of the coil and it is by means of this raised place that the inside end of a coil can always be told from the outside end, when there is no other way of telling it.



FIGS. 5, 6, 7 AND 8.

When the coils are otherwise marked, as they sometimes are, we do not have to even know which is the inside end and which the outside end, for then we have to do simply with like ends and unlike ends. If the two connecting lugs, L, L, Fig. 5, are on the end, they can be distinguished by the shape of the coil, which is rounded at the bottom to fit the shell of the motor; thus, if two coils lay side by side, tops up and pointing the same way, similar ends will be on the same side. On coils such as that shown by Fig. 6, where the lugs are on the side, sometimes the lugs are marked, sometimes they are shaped differently, and sometimes they are placed a little differently on the coil. If the coil has plain leads and no lugs, one lead will, as a rule, be longer than the other, as shown in Fig. 7. Where the leads or lugs are both on the same end of the coil it cannot be put in end for end, but where the leads or lugs are on the side, as in Figs. 6 and 8, such a thing can be easily done, with the result that the current goes into the wrong end of the coil and gives the wrong polarity to the field-magnet pole. To whatever cause the wrong connection may be due, it will have its effect upon the action of the car; if there are four coils, and one of them is reversed, the faulty motor will spark a little even when the two motors are in series, and will spark badly when they are thrown over to multiple. If two out of four fields are reversed, the car will not start at all on the faulty motor alone, but will start with the motors in series, because the good motor furnishes the starting power; the current simply passes through the bad motor as it does along any other conductor in the circuit. As soon as the motors are thrown over to multiple, the faulty motor probably grounds a brush holder, and the main motor fuse blows.

A very nice test as to the condition of the fields of a motor can be made by means of a 500-volt voltmeter. Let the car run on the fourth point, and hold the terminal lines of the voltmeter across first one pair of brush holders and then the other pair. On a 500-volt circuit each armature should cause a reading of about 240 volts. If the readings on the two are the same, it means that the fields are connected right; for if they were not, one field would be stronger than the other, inducing in its armature therefore a higher counter e.m.f. than that of the other armature, and there would take place across the stronger armature a greater drop in voltage than across the weak one. If in a test of this kind, then, one armature shows up a much larger drop than the other, it means that the fields on the low-drop armature are weak; this weakness may be due to the fact that one or more of the field coils are roasted or otherwise short-circuited, or that one or more of them are connected in wrong. Conditions go a long way toward indicating to which fault the trouble may be due. If the motor has just had a field put in, the chances are that there is something the matter with its connection. To find out to a certainty, the test described below may be used.

In Fig. 9, A, B, C and D are four fields that are known to be all right; F, G, H and J are the four fields in the motor itself. The motor fields and the standard fields are connected in series and a current sent through them. While the current is flowing, measure the drop from T to E, and that from E to rail. If both sets of fields are at about the same temperature and the two drops measure the same, the motor fields are not roasted or short-circuited, and the trouble must be due to a wrongly-connected coil. To find out which coil it is the car must be run in the house, the faulty motor opened, its armature taken out and the two shells closed again. A strong current must now be sent through the fields. When this is done, the fields become excited and send out lines of force between the various pole faces, across the armature chamber. If the fields are all connected right so that the poles alternate north and south, the lines of force will take the paths indicated by the dotted lines in Fig. 2; but if one of the coils is connected wrong, say the No. 1 coil, thereby making the No. 1 pole-piece N, instead of S, there will be three poles of one polarity, and only one pole of the opposite polarity, making the lines of force take the irregular paths shown in Fig. 10. Now if a piece of iron is put in among a lot of lines of force, it will adjust itself parallel to the general direction of the lines at the point where it is put in, if left free to move. In order to utilize this principle in testing the polarity of the pole-pieces, take a piece of iron rod about 4 ins. long and point one end in order to distinguish one end from the other by the touch and in talking about them. While the current is on the field reach down into the motor and pass the piece of iron from one pole to the other, holding it loosely in the fingers so that it can manifest a tendency to turn. Stick the blunt end on pole No. 1 and point the sharp end toward pole No. 2. If in its passage from one pole to the other it trys to keep the general direction shown by I′, in Fig. 2, the field is all right in between these two poles; if the same is true all around, the fields are all right and the coils are properly connected; but if in its passage from one pole to the other the iron rod shows a tendency to turn around, or to stand up straight in between the pole pieces, as shown at I^2, Fig. 10, the pole-piece that causes this on both sides of it, holds the wrongly-connected coil. If the coils are connected right, and there is a good strong field on the motor, it will be practically impossible to make the piece of iron stand up, as shown at I^2, in Fig. 10. This test is certain and is getting to be popular.

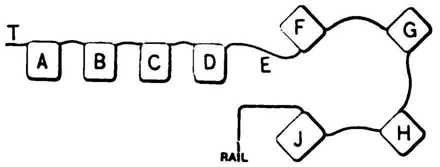


FIG. 9

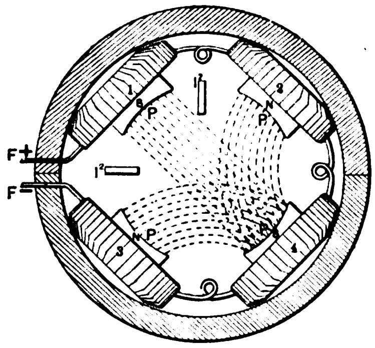


FIG. 10.

From the above can be drawn the conclusion that the way to connect field coils and have them right is to so connect the coils that the current goes out of the same end on one coil that it goes into on the neighboring coil; if it comes out of the long-lead end, or the bottom lug, or the bump side of one coil, the wire must connect to the long-lead end or the bottom lug or the bump side of the coil next to it. In other words, put the coils in the motor, if possible, so that the like ends of the coil lay next to each other, then connect these like ends together. This will leave two unlike ends to be connected to the car-wiring hose.

INTERIOR TELEPHONE SYSTEMS —III.

BY W. S. HENRY.

An arrangement devised by Mr. H. P. Clausen, and which does not infringe the Carty bridging bell patent, is represented by Fig. 14. A high-impedance magneto bell, C, is normally connected across the two lines by a two-point push button or other form of switch, which short-circuits the generator, G, as shown at Station 2. When the switch or push button, d, is depressed, the bell is put in parallel with a non-inductive resistance, f, of about 100 ohms, and the two are put in series with the generator, G, as shown at Station 1. The non-inductive coil, f, offers less resistance to the passage of the signaling current than the high-impedance bell magnet, so that the signal received at the oth-

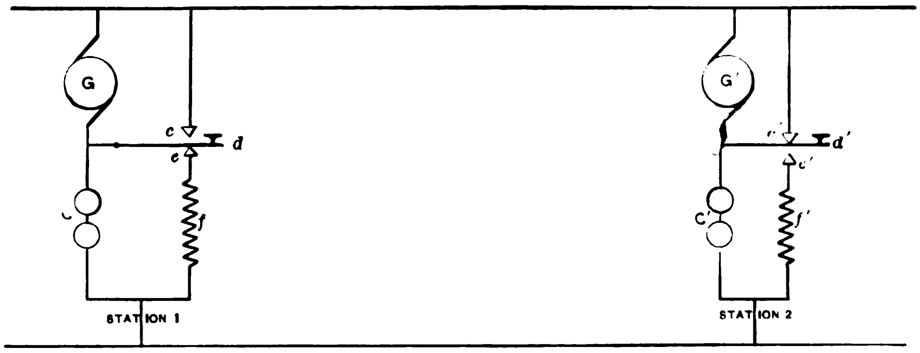


FIG. 14.—CLAUSEN BRIDGING ARRANGEMENT.

er end is stronger than it would be if the resistance, f, were not employed. This arrangement is obviously equivalent to adding about 100 ohms to the circuit near the signaling generator, but unless there is a large number of stations on the circuit this is not a serious disadvantage. In the ordinary bridging-bell system the local bell is connected directly across the terminals of the generator, as previously described and illustrated by Fig. 11, so that it takes slightly more current than any of the other bells on the line; in the arrangement here shown the current passing through the home bell is smaller than that passing out upon the line because it splits up between the non-inductive resistance and the bell magnet. Another advantage of the present arrangement from the standpoint of the manufacturer is that by removing the resistance coil, f, and the contact beneath the switch lever, the instruments are identical with those of the ordinary series system, so that a change from one to the other is easily made. In changing from the system shown by Fig. 13 to an ordinary series system, however, the high-impedance bell-magnet coils must be replaced by others of about one-eighth the impedance.

Fig. 15 shows two complete outfits containing the arrangement represented by Fig. 14. In place of the double-point push button or switch shown in Fig. 14 there is an arrangement on the spindle of the generator which performs the function of this switch automatically when the handle is turned. This device is shown in the position which it occupies while the handle is revolving at Station 1, and its position while at rest is shown at Station 2. The reference letters correspond with those in Fig. 14. One end of the generator armature winding is led out to the brush, b, and the other end is connected to the armature spindle, so that any connection made to the frame of the generator will connect with this terminal of the armature winding.

A patent has been applied for on still another method of connecting bridging bells and generators across two-line wires. This method consists in arranging the connections so that the bell and generator are normally in series across the line, thus presenting not only the impedance of the bell but also that of the generator to any alternating current that may flow in the line wires. When a push button is pressed the bell and generator are connected in parallel across the line wires. The bells are wound to have a high resistance and impedance, and the generators are wound to a low resistance, but to the high-frequency talking currents their impedance is very high; consequently since both the bell and generator are normally in series across the line at each station where the receivers are on the hooks there will be less leakage of the talking current from one line wire to another through the bells and generators than in the previously described bridging bell systems, where only the bell is across the line and the generator is cut out of the circuit. On the other hand, however, the ringing current also encounters the impedance (much lower now, however, since the frequency is so much less) of the generator armatures and bell magnets in series at all stations except the one where the generator is being used. It would be better, as far as the ringing efficiency is concerned, to wind more wire on the bell magnet, for with the extra turns thus gained a smaller ringing current would suffice. Furthermore, the bell at the station where the generator handle is being turned will get the benefit of the full potential at the generator terminals, while each of the other bells will get a potential smaller than this by the amount of the drop in potential through the generator armature in series with it. On account of the high impedance of the bell magnet and generator armatures when the two are in series, the ringing current will have a tendency to divide more equally between the stations along the line, thus giving better service than if the same bells were bridged directly across the line without having the generator armatures in series with them.

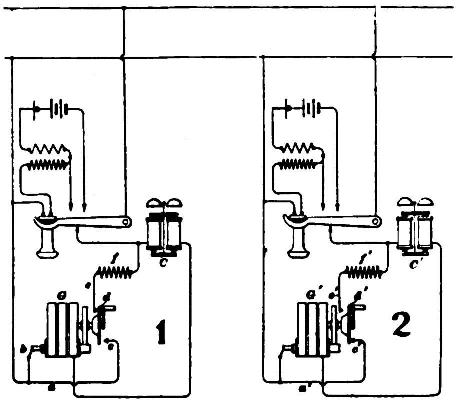


FIG. 15.

The arrangement described above is shown in Fig. 16. The interchanging of connections is accomplished by means of a special double-acting push button in which four springs, a, b, and a', b', are so arranged that in their normal positions a and b are electrically connected with each other but are not in contact with a' and b', the lower ends of which are free. In this, the normal position, it will be seen that the generator and bell are in series across the two line wires. To ring the bells the button, k, is pressed, which removes the contact springs, a and b, from the connection, c, and connects a with a' and b with b', thus throwing the bell and generator in parallel with each other across the two line wires. The receiver and transmitter circuits are connected as usual and so are not shown here.

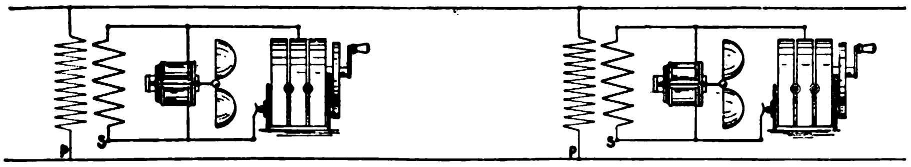


FIG. 16.

In all series magneto-bell telephones when an extension bell in some other part of the building is desirable, open the circuit in the generator box between the bell and the generator and there connect the two wires running to the extension bell. The idea is to connect the extension bell in series with the generator and the original bell so it will be cut out along with them when the receiver hook switch is up. Never put the extension bell directly in series with the line wire. In bridging bells an extension bell of high resistance and impedance may be connected anywhere across the two line wires.

Another system of connecting a number of telephones, bells and generators across two line wires, manufactured by the Holtzer-Cabot Electric Company, is shown in Fig. 17. For the sake of clearness, only the signaling apparatus is shown, and for two stations only. At each station there is a specially designed transformer, having a closed magnetic circuit of iron. The high-resistance winding, P, is connected directly across the line wires, and the low-resistance winding, S, is connected in the local circuit only, which also includes a low-resistance bell and an ordinary generator. When the generator is turned, the current divides, part going through the bell and the remainder through the winding, S, which acts as the primary of a step-up transformer, the winding, P, delivering to the line a current of higher potential. When this current reaches the other stations it goes through the windings, P, and is transformed back to the original potential, ringing the bells at all stations. The generator, G, is provided with an automatic cut-in switch or push button, as may be desired, arranged to normally keep the armature on open circuit. The bell may be placed in series with the winding, S, and the generator, in which case the generator should be provided with an automatic device or a push button that normally short-circuits the armature and re-

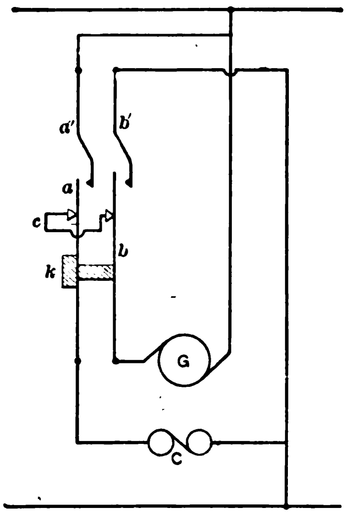


FIG. 17.

moves the short-circuit when the generator handle is turned.

The system has several advantages which offset more or less the loss due to the double transformation of signaling current. The transformer is small and very efficient and an ordinary series bell, which is both cheaper to make and more efficient than a bridging bell, can be used. The transformer has a complete magnetic circuit, and consequently the winding, P, offers a much higher impedance to the talking current than to the ringing current, greatly reducing the leakage; this impedance to the talking current is said to be much higher than that offered by a high-resistance bridging bell.

FEED WATER HEATERS.—II.

BY JAMES F. HOBART.

[In the preceding article the Hoppes Manufacturing Company of Springfield, Ohio, was erroneously referred to as the Hoppes Separator Company. The identity and correct name of the company are too well known, however, for the error to produce serious confusion.]

An important type of tubular heater using straight tubes is shown by Fig. 10. This is the Baragwanath heater, built by **Wm. Baragwanath & Son, Chicago.** It is steam jacketed, and is, in fact, a live steam heater. This type is valuable in certain cases for both purifying the water and heating it. The engraving shows the construction so plainly that no description is necessary. The builders make a plain tubular heater in which a single pipe connection can be used if desired, with excellent results; they also make horizontal open heaters, with or without pans.

The Jackson heater, illustrated by Fig. 12, is made by The Erie Machine Shops, Erie, Penn. This is a rather peculiar form of heater, fitted with straight tubes of brass, iron or copper, as desired. It will be seen that the steam goes directly through the heater, from side to side, while the water travels inside of the tubes, and passes through certain of the tubes in rotation. That is, the water does not go into one end of the heater and pass directly through all the tubes, but must pass first through certain tubes, and then through certain other tubes. In this manner the water is made to circulate a certain number of times through the heater, and gets more heat than if it only went once directly through. There is a safety valve at the top of the heater, adjacent to the water outlet, so that there is no danger of ever getting too much pressure inside of the tubes. The water inlet is at the bottom, and a blow-off is provided near this inlet. There are also several drips and blow-offs to take care of any sediment that may settle in the bottom of the shell.

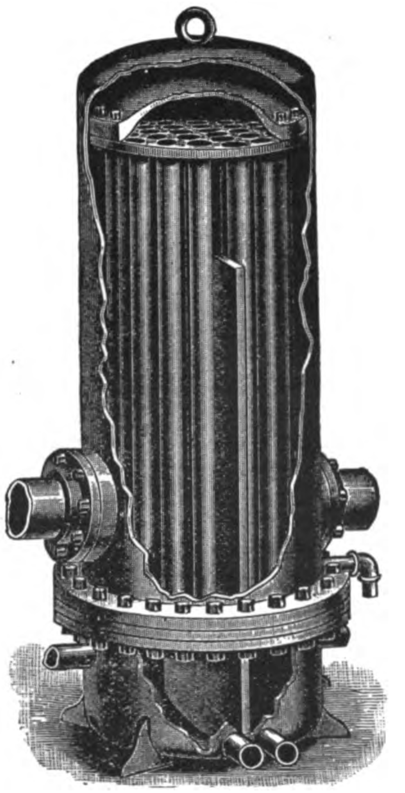


FIG. 11.—THE JACOBS HEATER.

The Jacobs is another straight-tube heater, shown by Fig. 11. It receives and delivers the exhaust steam at opposite sides near the bottom of the shell. The water enters and is discharged still closer to the bottom. There is, however, a separate head in the triple flange shown, and the tubes terminate in this head. The water thus has an opportunity to settle to a certain extent, and blow-off pipes are provided to take care of the sediment thus collected. There is a diaphragm extending from the bottom of the water space to the upper portion of the steam space, and dividing the area in the shell so that the steam and water must both pass over it and through all the tubes. There is no chance for either to pass directly through the heater and thereby come in contact with perhaps only a very few of the tubes. There is also a drip in the bottom of the steam space. By the peculiar construction of this heater both ends of the tubes are at all times exposed to the water and never to steam. It is due to this fact, and to the fastening of the tubes only to the lower tube-plate, that there is no leakage in the tubes of these heaters. They are made by Charles Jacobs & Co., of Boston, Mass.

There is another straight-tube heater, the Wainwright, made by The Taunton Locomotive Manufacturing Company, Taunton, Mass., in which expansion of the tubes is provided for, yet both ends of each tube are solidly expanded into the heads of the heater. In this form of construction the tubes are corrugated, so that expan-

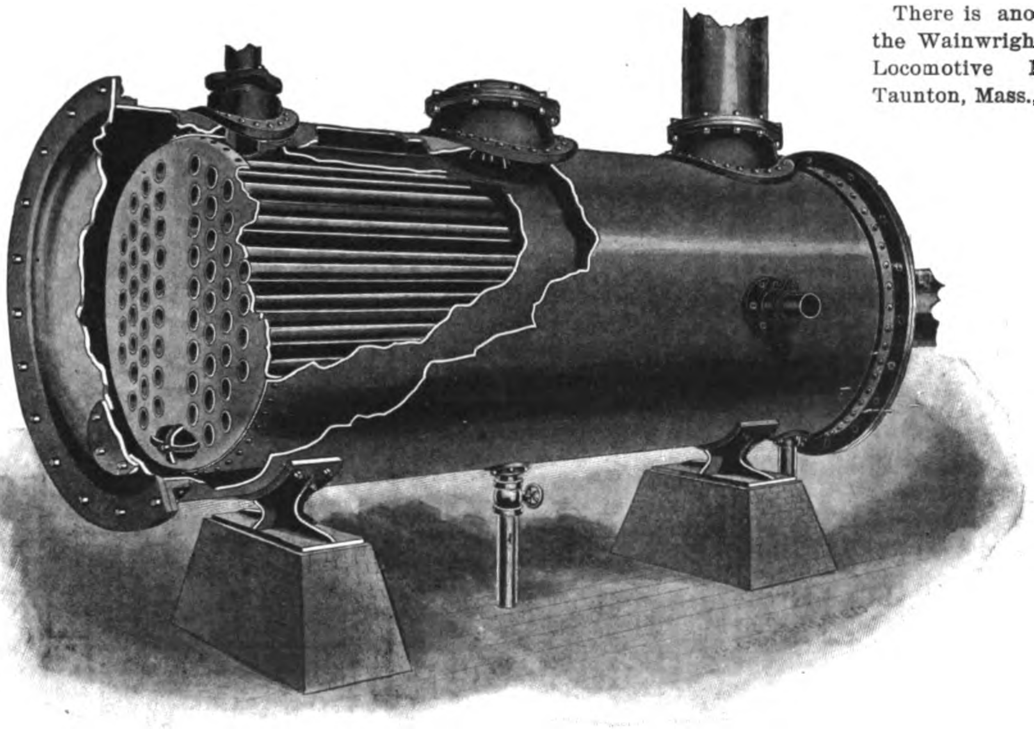


FIG. 10.—BARAGWANATH STRAIGHT-TUBE HEATER.

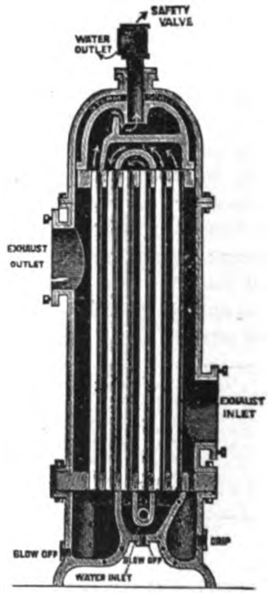


FIG. 12.—JACKSON STRAIGHT-TUBE HEATER.

sion is readily taken up in their length. The corrugations also serve to offer more surface to the action of the steam, which passes outside of them, and also causes a better circulation in the water by forming a lot of eddy currents which deflect the water from side to side, instead of allowing it to pass directly through the heater. The tubes are divided into sections by means of the radial partitions shown in the heads. The water is thus made to flow back and forth several times through the heater. There is another heater made by this concern, which is known as the Wainwright straight-line steam-tube heater. As shown by Fig. 14, this heater is intended to be made a portion of the exhaust pipe, and it is so arranged that the drip will not be interrupted by the enlargement of the exhaust pipe into a heater. To accomplish this, the bottom of the shell or case is simply made to line exactly with the bottom of the exhaust pipe, and the thing is done. Both of these heaters are made in vertical as well as horizontal forms.

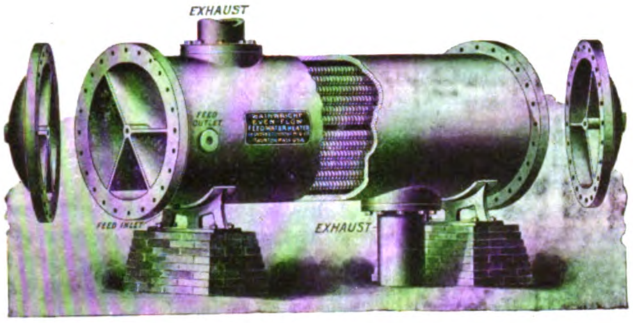


FIG. 13.—WAINWRIGHT EVEN-FLOW HEATER.

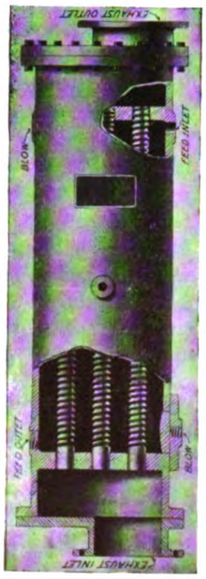


FIG. 14 - WAINWRIGHT STRAIGHT-LINE HEATER.

Fig. 15 shows a type of return tubular heater known as the Kensington, which is the exact reverse of the water-tube heater. In the Kensington heater the water goes in the shell, the steam in the tubes, and it is both a heater and a purifier as well. Formerly, most of the heaters were made in this manner, but without the improvements which are now incorporated in them. The engraving shows this heater in the vertical form, with the shell cut away to expose the drum head, through which the steam passes from one section of the tubes to the other. This type of heater is made by the Kensington Engine Works, Limited, of Philadelphia, who also build it in the U-type and in horizontal form.

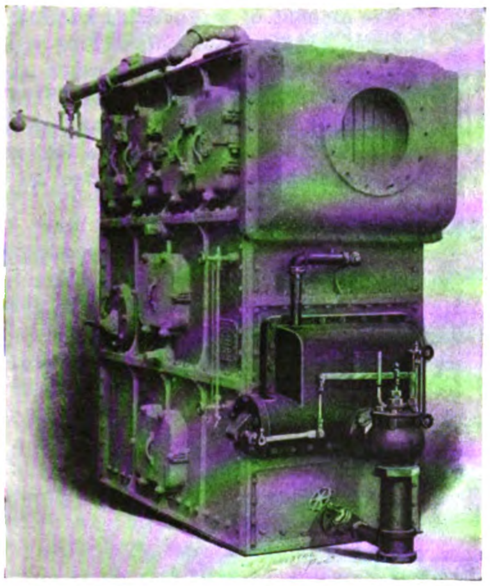


FIG. 16.—COCHRANE SPECIAL HEATER AND RECEIVER.

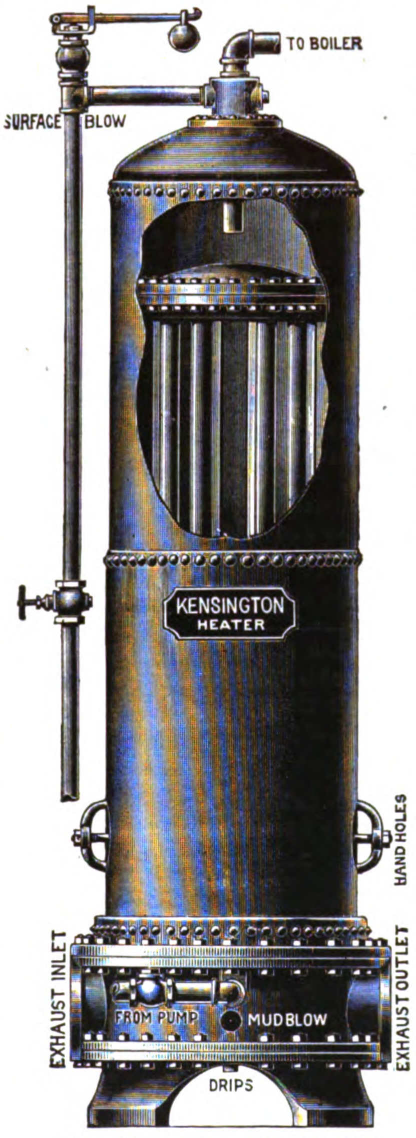


FIG. 15.—KENSINGTON HEATER.

The open heater is one which gives splendid results, although much abused by many engineers and steam users. Still there is a field, and a wide one, for this type of heater in which no other type will give the same efficiency. This may sound like rank treason to some, but it is the truth nevertheless. Heaters of this type, shown by Figs. 16 and 17, are the well-known Cochrane, built by the Harrison Safety Boiler Works, Philadelphia. They have the distinction of being without tubes, but contain trays or pans for the separation of grease from the water. Not only does this apparatus heat and cleanse the feed water, but it regulates the quantity thereof as well; the mechanism for accomplishing this needs little attention and is readily accessible.

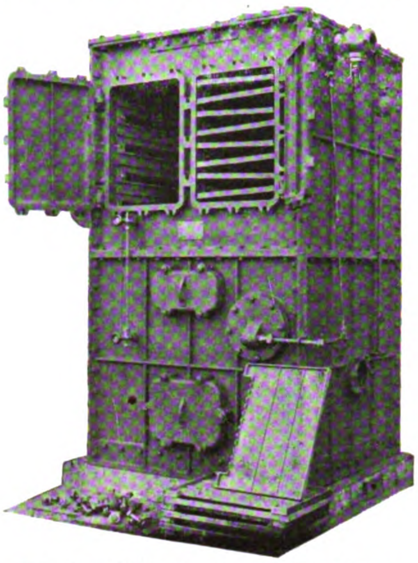


FIG. 17.—1500-H.P. COCHRANE HEATER AND PURIFIER.

There is one other type of heater which must be noted, namely, the "Vacuum," made by Warren Webster & Co., Camden, N. J.; this heater is known also as the Webster heater. The special feature is the arrangement for positively and independently removing the air liberated from the feed water in the upper part of the heating chamber. This is done by a suction injector or a pump, the air inlet being provided with an automatic valve.

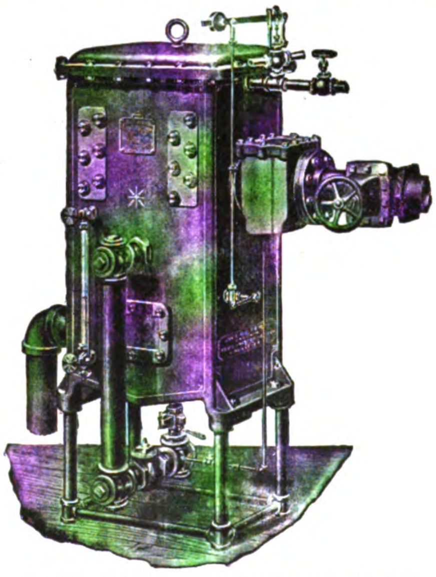


FIG. 18.—WEBSTER FEED WATER HEATER AND PURIFIER.

The casing also contains a series of inclined copper trays which spreads the water over a large surface and heats it very quickly when in a finely divided state, the absorption of steam being accomplished by direct contact. (See Fig. 19.) The builders claim for this heater the ability to effect an economy in the operation of any steam plant. They also build a number of other types of heaters.

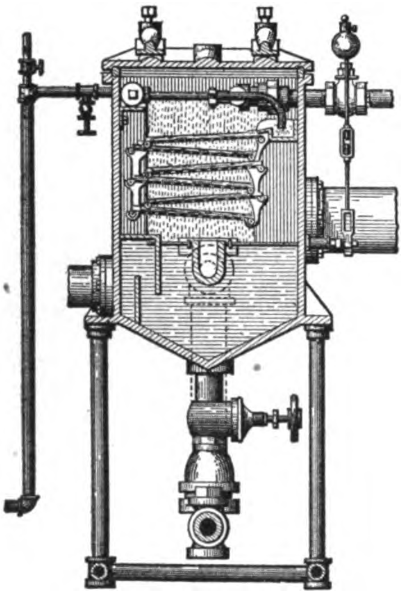


FIG. 19.—SECTION THROUGH WEBSTER HEATER.

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Lessons in Practical Electricity

TRANSFORMERS.

While the reader may never desire to design a transformer, an understanding of the relations existing between the magnetic flux, e.m.f., current and windings, will greatly facilitate the handling of the apparatus in everyday practice. The principles which govern the action of a dynamo armature also apply to transformers.

The primary induced e.m.f., E_o, is given by the formula:

$$\frac{4.45 \times c \times \Phi \times N_p}{100,000,000} = E_o \text{ ....(1)}$$

in which n = the frequency,

Φ = the maximum magnetic flux, and

N_p = the number of turns in series in the primary winding.

The frequency is measured in cycles or complete reversals per second; the maximum magnetic flux is the number of lines of force in the core when the flux is at its maximum as represented by the highest and lowest parts of the curve marked "exciting current and flux" in Fig. 7, which is repeated here. The above formula also gives the secondary induced e.m.f., e_1, when the number of secondary turns, N_s, is substituted for the primary turns, N_p because, as explained in a previous lesson, the variations in the flux in the core affect both windings. It will be simpler, however, to consider only the primary relations at first.

Formula (1) enables one to determine the induced e.m.f., provided the various factors are known. The frequency, n, is always known, of course; the flux value, Φ, depends on the cross-section of the core and the density of the magnetic lines; and the number of turns of wire, N_p, is dependent on the other factors. In practice, the value of E_o is so nearly identical with that of the impressed e.m.f., E, that for preliminary calculations they are assumed to be the same, making the formula read

$$\frac{4.45 \times n \times \Phi \times N_p}{100,000,000} = E \text{ ....(2)}$$

As the impressed e.m.f. is known, the formula is better transposed into

$$\frac{100,000,000 \times E}{4.45 \times n \times \Phi} = N_p \text{ ....(3)}$$

from which the requisite number of primary turns may be ascertained.

The maximum value of the flux, Φ, is not widely variable; it has been found that for the common frequency of 133 to 140 cycles the density should not go much higher than 20,000 lines per square inch in order that the transformer may be used also on lower frequencies, and it need not be less than 16,000 lines per square inch for good all-around efficiency; a fair average value is 18,500. As the total flux is the product of the density and the area of the core cross-section, the symbol, Φ, may be replaced by

$$18,500 \times A,$$

A being the cross-section in square inches and 18,500 the density in lines per square inch. This changes formula (3) into

$$\frac{100,000,000 \times E}{4.45 \times 134 \times 18,500 \times A} = N_p;$$

and this may be reduced without appreciable error to read

$$\frac{E}{11 \times A} = N_p \text{ ....(4)},$$

which makes the calculation for the number of primary wires perfectly simple. It should be borne in mind always that this formula is based upon a magnetic density of 18,550 lines per square inch at a frequency of 134 cycles.

If a transformer be changed from a 133-cycle circuit to a 60-cycle circuit of the same potential, the magnetic density will increase automatically to practically $\frac{133}{60}$ times the original density. The explanation of this is that the induced or counter e.m.f. of the primary must be equal to the impressed e.m.f., minus the drop in the winding, which is insignificant. The counter e.m.f., E_o, varies directly with the frequency, the flux and the number of turns, as shown by formula (1); the frequency being reduced, something else must be correspondingly increased, and as the number of wires cannot change it must be the flux that increases. This is accomplished automatically by an increased flow of magnetizing current.

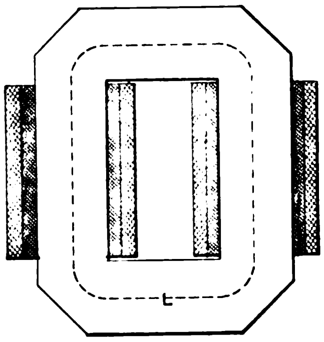


FIG. 17.—LENGTH OF MAGNETIC PATH.

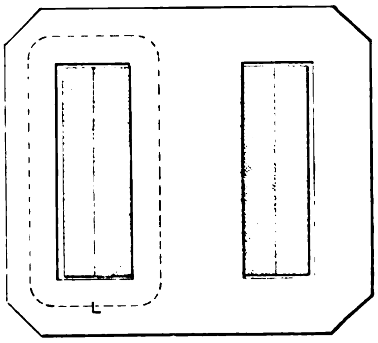


FIG. 18.—LENGTH OF MAGNETIC PATH.

The amount of magnetizing current demanded by a transformer may be readily approximated, although it cannot easily be predetermined with great accuracy on account of the magnetic leakage of lines of force. Assuming nq leakage whatever, the magnetizing current is given by the formula

$$\frac{.2215 \times B \times L}{\text{Permeability} \times N_p} = M,$$

in which B is the maximum flux density per square inch; L, the length of the magnetic path in inches; N_p the number of turns in the primary winding, and M the magnetizing current with the secondary

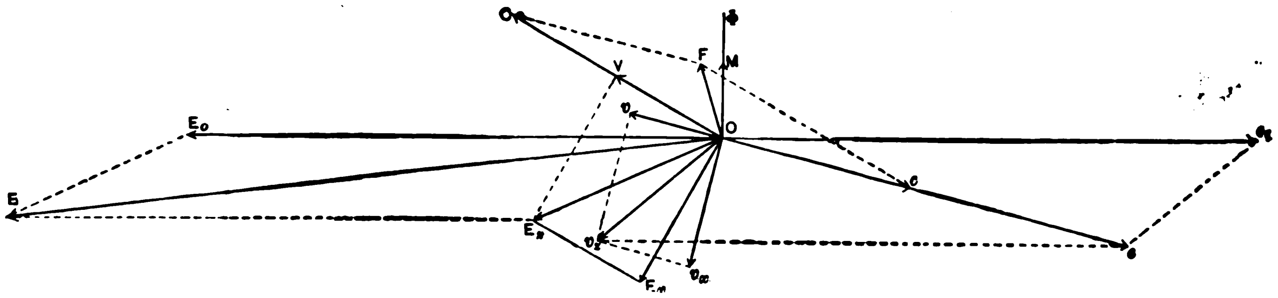


FIG. 16.—COMPLETE DIAGRAM OF PHASE RELATIONS WITH A NON-INDUCTIVE LOAD ON THE SECONDARY.

open. The permeability of transformer iron varies according to the density of the magnetic flux; the greater the density, the greater the permeability, up to about 40,000 lines per square inch; beyond this the permeability decreases as the density increases. At the densities employed in transformers the permeability ranges from 2000 to 2500; taking 2215 as an average value, for convenience, the formula above becomes

$$\frac{.2215 \times B \times L}{2215 \times N_p} =$$

$$\frac{B \times L}{10{,}000 \times N_p} = M \ldots\ldots\ldots\ldots (5).$$

Figs. 17 and 18 indicate what is meant by the "length of the magnetic path in inches;" the path, L, being indicated by dotted lines. Fig. 17 is a cross-section of a core-type transformer, and Fig. 18 that of a shell-type transformer.

The magnetizing current, M, is not the whole primary current with the secondary open; there is also required a "core-loss" current, h, Fig. 11, the phase of which is 90° from the phase of the magnetizing current, M. The resultant of these two is the primary exciting current, C, when the secondary is open. The determination of the core-loss current will be explained in the next lesson.

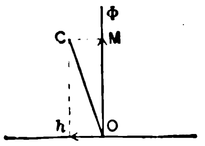


FIG. 11.—SHOWING THE DIFFERENCE OF PHASE BETWEEN THE MAGNETIC FLUX AND THE EXCITING CURRENT DUE TO CORE LOSSES.

◆

Letters on Practical Subjects

Removing Insulation from Line Wires.

To the Editors, American Electrician;

Sirs:—The following kink in removing insulation may be known to some of your readers, but it will probably be interesting to a good many others who have not found it out for themselves. I have found that in removing insulation from wires for the purpose of making joints, etc., the easiest method is to crush the insulation with a hammer or with a pair of heavy plyers, after which crushing it can be removed easily with the fingers. Of course the wire must not be hammered hard enough to injure the copper, and it is not necessary to do this in order to crush the insulation sufficiently to remove it. Where insulation has to be removed from a considerable length of wire it can be more quickly and uniformly crushed by running the wire through rollers. I find this plan very rapid and very much easier than removing insulation in the old way with a knife, which is not only tedious, but usually involves injury to the wire and always ruins the knife. M. A. Johns.

San Diego, Cal.

◆

Peculiar Switchboard Instrument Readings.

To the Editors, American Electrician;

Sirs:—We have an alternating-current single-phase station operating at 1100 volts primary e.m.f. In comparing the readings of a wattmeter with those of a voltmeter and ammeter recently, I obtained the remarkable result of a higher reading at the wattmeter than the product of the voltmeter and ammeter readings, which I do not understand. The wattmeter, after running an hour, registered 1800 watt-hours, which is, of course, equivalent to a rate of 1800 watts. The series windings of the wattmeter were connected directly in the primary circuit and the potential windings were supplied from a 55-volt transformer. The ammeter and voltmeter showed 20 amperes and 1100 volts respectively, which equals 22,000 watts, or 22,000 watt-hours at the expiration of one hour. Multiplying the 1800 watt-hours registered by the wattmeter by the ratio of transformation (20) gives 36,000 watt-hours, so that the true watts seemed to have been about 50 per cent greater than the apparent watts. Can someone account for this? H. A. Hildebrandt.

St. Peter, Minn.

◆

E. M. F. and Difference of Potential.

To the Editors, American Electrician;

Sirs:—In your February issue an article appeared on "Difference of Potential and Electromotive Force," which fails to make clear the distinction between the two, if such a distinction is possible or required. In the first place the galvanometer circuit and the closed conductor are two entirely different circuits, and it is illogical to draw conclusions concerning the latter from the action of the former, in the case cited.

The fact that the diametrically opposite connections show no difference of potential is but what occurs in a Wheatstone bridge when the resistances in the arms balance, as is supposed to be true in the case referred to—that is, the wire is of uniform resistance. Then because there is no potential difference between these two points, a, b, it is not reasonable to say that there is no potential difference in the closed conductor.

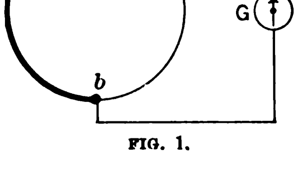


FIG. 1.

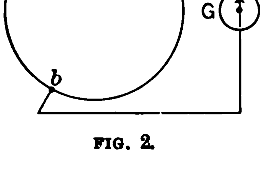


FIG. 2.

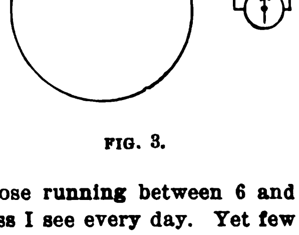


FIG. 3.

If, as was stated, the resistances of the halves of the coil are unequal, then a potential difference will exist in this, the galvanometer circuit.

This is shown in Fig 1, which is the same electrically as Fig. 2, where the closed conductor is uniform in resistance and the galvanometer leads are connected other than opposite. Carrying one connection around still further, as in Fig. 3, we see that there is a potential difference in this section of wire. Adding up like sections for the entire conductor we get the total potential difference or e.m.f. in the closed conductor.

This seems to prove that there is no difference between potential difference and e.m.f. It is incorrect to say that the potential difference is due to the e.m.f., because the potential difference or e.m.f. is due to the cutting of lines of force, or induction.

The distinction that I have been accustomed to make is to speak of the e.m.f. as the potential difference in a closed circuit and of potential difference as the e.m.f. on open circuit. The difference being one only of application of terms.

F. Hardie Jeannin.

Schenectady, N. Y.

◆

Poor Incandescent Lighting Service and Municipal Ownership.

To the Editors, American Electrician;

Sirs:—After reading the very interesting article by Mr. Willcox in the May issue, I believe he is right as far as he goes, but he does not go deep enough into the subject to give it fair treatment. Why blame all on the lamps, which have done marvelously well indeed in surviving the abuse already heaped upon them? It is not sufficient to stop at the lamp, for that could easily be controlled by the station. Passing on to the other apparatus, one will find imperfections of a far more permanent character than the life of a lamp.

In the first place, nine-tenths of the fixture work that is done in the United States is unreasonably poor. A great percentage of the switches are overloaded, and the interior wiring done up to a year or two ago was mostly of a nature which should entail universal condemnation. What percentage of buildings wired in the entire country have two per cent or less loss is a question I would enjoy reading about; those running between 6 and 10 per cent loss I see every day. Yet few people realize that they are paying anywhere between 10 and 20 per cent more for their lighting than they would pay if conditions were right. In other words, if all conditions were as nearly perfect as good management could make them, I really believe that consumers would save 25 per cent on their bills and could easily afford to pay for current at a rate five per cent higher than under existing conditions. This would allow central stations to pay better dividends to the stockholders.

Speaking of dividends, it seems remarkable that so many electricians, having no more business ability than the average merchant has of electrical ability, have sufficient egotism to imagine themselves capable of coping with far-headed business men of the world. Get men of business ability to run the offices of central station plants and then many central station troubles will speedily disappear.

If a slight digression may be permitted, I would like to say a word on the subject of municipal ownership. At a recent convention able electricians spent much valuable time in discussing and condemning the municipal ownership of electric lighting stations. Does anybody remember ever hearing a lot of real-estate dealers condemn municipal corporations for owning their public buildings because they might be able to make a profit in renting offices, or because the municipalities might save money? Municipal lighting stations should be the finest in the country and at such stations experiments of a costly character should be carried on as well as efficiency tests and kindred trials, without regard to expense and having only in view the perfection of apparatus and benefit to the public at large. I believe that time will prove my views in this direction to be not without foundation.

M. A. de Lew.

Sacramento, Cal.

A Transformer Trouble.

To the Editors, American Electrician;

Sirs:—I have frequently noticed that immediately upon putting a transformer in circuit the humming was much stronger and apparently a lower pitch than under normal conditions; after a few moments, however, the humming weakened and the pitch rose to the normal. This does not always occur. I recently tested a 2-kw. transformer for core loss in the secondary end and to determine the apparent watts used an ammeter and voltmeter. The normal current was 1.3 amperes. I noticed the deep-toned humming on this transformer also and turned the current on and off repeatedly in order to note the result. Sometimes the ammeter showed normal deflection and sometimes indicated much greater than normal current. Finally, simultaneously with an unusually loud humming, the ammeter needle was deflected to the full extent of the scale, 10 amperes, and would have gone farther if possible.

Some of your readers may be interested in reasoning out the cause of the abnormal rush of current as well as the variation in the humming noted above.

C. A. Kuehn.

Canton, Ohio.

Electrical Catechism

486. What is a multiple circuit?

A multiple circuit is one that is branched so that the current divides in several paths. Such a circuit may be called "multiple arc," "multiple," "parallel," "branched," or "divided." The parts may be said to be connected "in multiple," "in parallel," "in multiple arc," "in derivation," or "in shunt."

487. What is the resistance of a multiple circuit?

It is obtained most easily by considering the conductivity which is the reciprocal of the resistance. The conductivity of the whole equals the sum of the conductivities of the parts, hence the resistance of the whole equals the reciprocal of the sum of the conductivities; or the resistance of the whole equals the reciprocal of the sum of the reciprocals of the resistances of the separate parts. For a circuit of three branches, this may be expressed in a formula as follows:

$$R = \frac{I}{K} = \frac{I}{K' + K'' + K'''} = \frac{I}{\frac{I}{r'} + \frac{I}{r''} + \frac{I}{r'''}} = \frac{r'\,r''\,r'''}{r'\,r'' + r'\,r''' + r''\,r'''}.$$

The formula may easily be extended to suit any number of branches. One way of expressing the joint resistance is to say that the resistance of a branched circuit equals the product of all the parts divided by the sum of the products of each part by every other part except one. When the parts are equal, the formula reduces to a simpler form, and the joint resistance equals that of one part divided by the number of equal parts.

488. Give an example of a branched circuit with equal parts.

Take a circuit with 10 16-candle 110-volt incandescent lamps in multiple. The resistance of one lamp is about 220 ohms; the resistance of the group is 220 divided by 10, or 22 ohms. This can be checked easily; the resistance of one lamp being 220, it takes 110 divided by 220, or 0.5 ampere; each lamp takes an equal amount, so the ten lamps would take 10 times 0.5, or 5 amperes; by Ohm's law, when the current is 5 and the voltage is 110, the resistance is 22 ohms.

489. Give an example of a branched circuit with unequal parts.

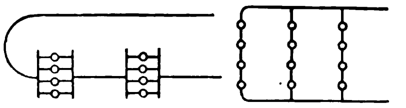
An incandescent lighting circuit divides into three circuits having 5, 8 and 10 lamps respectively. The resistances of these branches are therefore 44, 27.5 and 22 ohms; their conductivities are 0.0228, 0.0364 and 0.0455 "mhos"; the sum of their conductivities is 0.10465 mho, and the reciprocal of this sum is 9.55 ohms. This may be checked as follows: The first branch takes 110 divided by 44, or 2.5 amperes; the second branch takes 4 amperes and the third branch 5 amperes, making a total of 11.5 amperes; to take this current, the resistance is 110 divided by 11.5, or 9.55 ohms.

490. What is a "mho"?

The mho is the unit of conductivity and is the reciprocal of the resistance of one ohm. It is the conductivity of a conductor whose resistance is one ohm.

491. What are series-multiple or multiple-series circuits?

Practice is somewhat divided in the use of these words. With some, a multiple-series circuit means a circuit consisting of a multiple of series circuits; others mean multiple circuits in series. The two are suggested in the accompanying figure. Examples of multiple-of-series circuits are seen in the lighting circuits of street cars, in which five incandescent lamps are connected in series and several of these circuits are connected in multiple across the 550-volt line. Series-of-multiple circuits were formerly used for operating incandescent lamps on arc circuits, the current being divided among several lamps so that each lamp took only part of the whole current; these systems proved to be sources of fire risk and have been abandoned.



492. Are multiple-series circuits used for any purpose except for lighting from electric railway circuits?

Incandescent electric lamps for street lighting purposes are commonly operated on multiple-series circuits. The "municipal system" formerly sold by the Edison Company, had a direct current dynamo, giving about 1200 volts. A "string" of twenty or more incandescent lamps taking 4 amperes were connected in series with an adjustable lamp board or "bank board" having an ammeter and a number of lamps which could be switched into the circuit when needed. Several strings of lamps were connected to one dynamo, enough lamps being in each circuit so that the 1200 volts would send the required 4 amperes through the circuit. The figure shows the circuits and also the principle of the system. Similar circuits are operated from the 1000-volt alternating current systems, each circuit having a bank board in circuit at the station. The Westinghouse Company has a system slightly different, in which there is no bank board at the station, but each lamp has a shunt coil which takes care of the circuit in case a lamp breaks. With the alternating current systems, the street incandescent lamps and the lights inside buildings are operated from the same machines and may be operated from the same circuits if desired.

493. What is the difference between a conductor and a resistance?

It is a question of degree and purpose. No substance is a perfect conductor, therefore every conductor offers more or less resistance to a current. If one wishes to increase the resistance of a circuit, he puts in series a conductor of the desired resistance. If he desires to reduce the resistance, that is, to increase the conductivity of the circuit, the conductors are replaced by others of higher conductivity, or several conductors are connected in multiple.

494. What determines the resistance of a conductor?

The resistance increases directly as the length, inversely as the sectional area and depends upon the "specific resistance" of the material of which the conductor is composed.

495. What is meant by specific resistance?

The specific resistance is commonly taken as the resistance, in millionths of an ohm, between the parallel faces of a cube of material one centimeter in each dimension. In practical engineering the resistance of a mil-foot is often taken as the unit. Values for substances commonly used as conductors are given in the following table:

SPECIFIC RESISTANCE OF CONDUCTORS.

Conductor.	Specific resistance (microhms per cubic centimeter)	Resistance of one mil.-foot.		Temperature coefficient per degree Centigrade.	Percentage conductivity.
		0 Cent. 32 Fahr.	24 Cent. 75 Fahr.		
Copper....	1.594	9.59	10.507	00388	100.
Silver.....	1.50	9.4	10.16	.00380	106.
"EBB" iron....	9.75	58.6	65.3	.00463	16.2
"BB" iron.	....	.....	78.5	......	13 5
Steel (wire).		....	90 8	. . . .	11.6
Aluminum.....	2.889	17.75	19.4	.0039	54.5
Lead ...	19.63	115.5	129.	.005 ?	8.2
Mercury........	94.07	600.	613	.00089	1.73
German silver..	20 76	126.	127.2	.0004	8.3

The resistance of any temperature (above zero) equals the resistance at zero multiplied by one plus the "temperature coefficient" times the temperature (in Centigrade degrees). This is expressed by the formula,

$$R_t = R_0 \ (1 + x\,t).$$

496. What is a microhm?

A microhm, or micro-ohm, is one millionth part of an ohm.

497. What is a circular mil?

The circular mil is the unit used in measuring the area of conductors. It is the area of a circle whose diameter is one mil; that is, one one-thousandth of an inch.

498. What is a square mil?

The square mil is sometimes used as a unit of area, being the area of a square one one-thousandth of an inch on each side.

499. What is the relation between circular mils and square mils?

The number of circular mils multiplied by 0.7854 gives the number of square mils. Square mils multiplied by 1.273 equal circular mils. These figures give the relation between the area of a circle and the surrounding square.

500. What is a mil-foot?

The mil-foot is a wire of cylindrical section having a diameter of one mil (that is, one one-thousandth of an inch). The resistance of a mil-foot of pure copper at the temperature of melting ice is 9.59 ohms; at 75 degrees Fahrenheit it is 10.51 ohms.

501. Is the resistance of a conductor affected by the temperature?

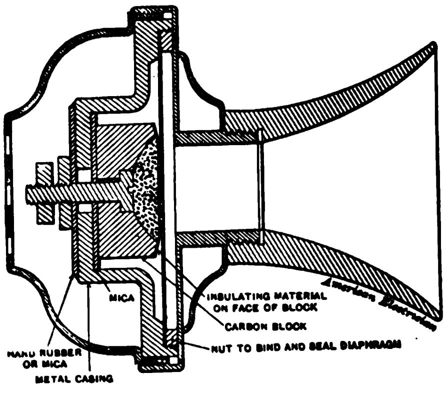
The resistance of metal conductors increases about four-tenths of one per cent. for each degree Centigrade rise in temperature, or about twenty two-hundredths of one per cent. for one degree Fahrenheit. The resistance of carbon, of liquids and of a few alloys decreases with a rise of temperature.

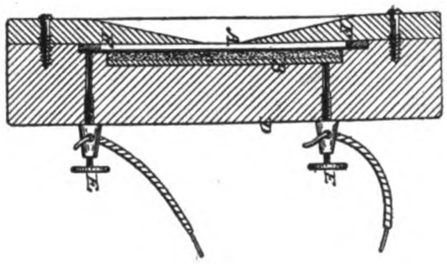
502. Is resistance affected by pressure?

The resistance of a solid continuous conductor is not affected by pressure. The resistance of a conductor containing loose connections, such as a powder or a pile of plates lying loosely upon one another, is diminished by pressure, since the parts are brought closer together. The resistance at the surface of carbon is more sensitive to pressure than that of other substances, and this has been usefully applied in certain forms of carbon rheostats, also in the telephone transmitter.

503. How is the variable resistance of carbon utilized in the telephone transmitter?

This may be illustrated from the Hunnings transmitter, which is the basis of most modern transmitters. In the accompanying figure, C represents granulated carbon which is held between a solid back, B, and the diaphragm, A, so that the circuit between the binding posts EE is through the back, B, the carbon particles, C, and the diaphragm, A. When a person speaks in front of the transmitter, the diaphragm is thrown into vibration and thus presses against the carbon particles more or less, and so varies the resistance, and consequently the current varies with each vibration of the voice. The figure shows also an improved modern form.





Queries and Answers

Why are man-hole and hand-hole covers in a boiler made oval instead of round?
W. S. L.

Because the cover of the man-hole must be larger than the man-hole itself, and if the hole were round the cover could not be inserted through it.

How can I get rid of cross induction on a telephone circuit of No. 12 galvanized-iron wire, running parallel on the same poles with electric-light wires?
C. J. S.

By transposing the telephone wires at intervals of two or three pole spans.

Has an alternator ever been built to give 500,000 volts?
C. K.

No. Such a machine is impossible in the present state of the art and probably will remain so, as such a potential cannot be insulated.

Where can I obtain a diagram for the closed-circuit burglar alarm system?
A. H.

From any of the manufacturers of such apparatus, notably Partrick & Carter Company, Holtzer-Cabot Company, Westtern Electric Company, and many others.

How many poles are there on Walker and Westinghouse street-car motors, and how many circuits are there through the armature? (2) Are the commutators cross-connected?
H. S. R.

All standard street-car motors are four-pole machines and the armatures have two-path windings. (2) No.

How are logarithms used in finding the square, cube, or other powers of a number?
N. A. L.

Multiply the logarithm of the number by the exponent; the result is the logarithm of the power. As a simple example, 5^2 is obviously 25; the logarithm of 5 is .69897 and multiplying this by 2 (the exponent of 5^2) gives 1.39794, which is the logarithm of 25.

How is the frequency of an alternator determined?
C. B. H.

By the number of poles and number of revolutions of the armature. The frequency in periods per second is found by multiplying half of the number of poles by the number of revolutions per second. The alternations are equal to twice the frequency in periods, as two alternations constitute a period.

How is it that the same transformer can be used on circuits of either 60 cycles or 133 cycles? (2) If the back e.m.f. of the transformer is proportional to the frequency, will not a 133-cycle transformer be overheated when run on a 60-cycle circuit?
C. S. E.

Because the density in the transformer core rises automatically, so that although the frequency is less than half the product of the frequency, the number of lines of force, and the number of turns of wire remains practically the same on the 60-cycle circuit that it was on the 133-cycle circuit. (2) No, for the reason just given.

Why is low voltage on a railway circuit injurious to the motors? H. K. C.

Because the amount of power required to drive the car is roughly proportional to the product of the voltage and the current passing through the motor, and if the voltage is low the current taken by the motor must be greater in order to do a given amount of work; consequently the motors overheat.

Does water always boil at 212 degrees? F. A. W.

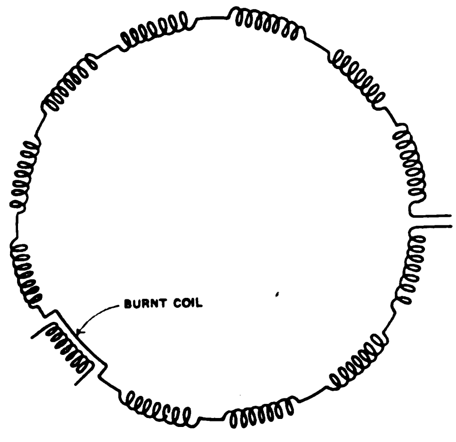
Pure water boils in the open air at 212 degrees, at an altitude where the barometer reading is practically 30 ins. In a boiler, the boiling temperature is determined by the pressure upon the water; the higher the pressure the higher the boiling point. Any table of the properties of steam will give you the temperatures corresponding to various boiler pressures. The boiling point of greasy or salty water is higher than that of pure water, for a fixed pressure.

What sizes of wire will be needed in the windings of the 1-h.p. motor described in the January and February issues of the American Electrician in order to run it from the storage battery described in the February, 1899, issue, and how many storage cells will be required? T. T. R.

For the armature winding use wire six gauge numbers larger than the wire specified in the article or else use two wires in parallel, each three gauge numbers larger than that specified; for the field winding use wire seven gauge numbers larger than specified. You will require 15 cells of storage battery to operate the motor with this winding.

I have a 50-kw. 12-pole 2000-volt alternator which occasionally burns an armature coil; can I not cut out the damaged coil and continue running until I can replace it? G. P.

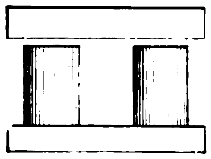
You can cut out a burnt armature coil on your alternator as indicated by the sketch herewith. You must be sure, however, to leave both ends of the burnt coil entirely disconnected from the remainder of the winding so that it will not be short-circuited, and will also not form a path from the sound winding to the core.



Will the motor described in the December, 1898, issue of the American Electrician work in a satisfactory manner if I substitute an armature core of soft iron instead of one of charcoal iron? F. B.

The motor will not work satisfactorily with an armature made of solid iron, if that is what you mean. If you mean soft sheet iron, however, this can be used, but it will cause the motor to run somewhat warmer than if charcoal iron be used. If you are not careful to obtain thoroughly annealed sheet iron with little or no manganese in it, the result will be that your armature core will run so hot that the machine will be practically useless.

I have an electromagnet frame and an armature piece like the enclosed sketch; can I not make a transformer by winding coils on the two round legs and screwing the armature piece to the upper ends? C. B. C.



No; a transformer core cannot be made of solid iron, but must be built up of very thin sheet iron of an especially good grade.

How can I calculate the ampere-turns required to obtain a given magnetic flux in the core of an electromagnet? (2) Is the protection afforded by a good lightning conductor on a building absolute? (3) How can I predetermine approximately the current allowable for a magnet coil? J. A. R.

(1) The accompanying table will give you approximately the number of ampere-turns required to force magnetic flux through iron per inch length of path at various densities; also the ampere-turns required per inch length of path through air. It is only necessary to determine at what density you wish to work; measure the length of the path in iron, multiply this by the number given in the table for the density assumed, and you have the ampere-turns required for the iron part of the circuit. Next calculate the density that you will have in the air portion of the circuit, multiply the table ampere-turns corresponding to this density by the length of the path through the air and you have the ampere-turns for the air-gap or gaps; add these to the result previously obtained and you have the total number of ampere-turns required. This is at best only an approximation because the quality of iron may differ from the average values from which the table was prepared. Moreover, it is impossible to determine accurately the amount of leakage which you will have. (2) No; it is impossible to confine a lightning dicharge to a conductor. The most that a good lightning conductor can do is to tend to carry off the discharge without damage to the building, but there is no certainty about the result. (3) Compute the area of the outer surface of your magnet coil in square inches; multiply this by 0.6 and divide the product by the resistance of the coil. The square root of this last result will give you approximately the current that the coil will stand. Expressed in the shape of a formula this rule is as follows:

	—Ampere-turns per inch length.—			
Magnetic Density.	Wrought iron.	Cast Steel.	Cast iron.	Air.
25,000	4½	5¾	32	7,833
27,500	5	6¼	36	8,616
30,000	5½	6¾	42	9,400
32,500	6	7¼	48	10,183
35,000	6½	7¾	55	10,966
37,500	7	8¼	63	11,750
40,000	7½	8¾	74	12,532
42,500	8	9½	85	13,315
45,000	8½	10	97	14,100
47,500	9	11	112	14,882
50,000	9⅔	12	130	15,665
55,000	11¼	14	175	....
60,000	13	16½	240	....
65,000	16	19½	...	....
70,000	20	23	...	....
75,000	25	27	...	....
80,000	32	34	...	....

$$\frac{0.6 \times \text{Sq. ins.}}{\text{Resistance}} = \text{Current}^2$$

How many horse-power would be required to run a 20-h.p. motor at normal speed under full load as a dynamo? What would the electrical output be? E. P. M.

This depends on the efficiency of the machine. The formulas below give the relations:

$$\frac{\text{Mech. ability} \times 746}{\text{Efficiency.}} = \text{Elec. ability ;}$$

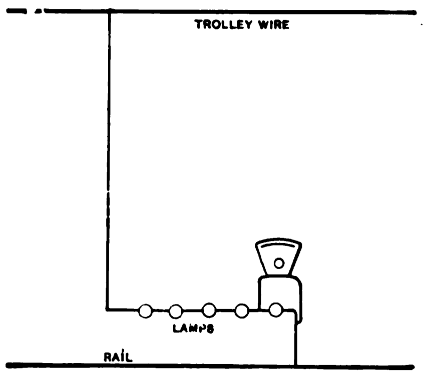
$$\frac{\text{Elec ability}}{\text{Efficiency} \times 746} = \text{Driving power ;}$$

$$\frac{\text{Mech. ability}}{\text{Efficiency}^2} = \text{Driving power.}$$

Mechanical ability and driving power are in horse-power, and the electrical ability is in watts.

What is the best way to test the voltage between a trolley line and a rail (anywhere on the line) when you only have a voltmeter? (2) Will it make any difference which of the binding posts is made negative or positive? J. H. N.

The only way to test the voltage between a trolley line and a rail is by means of a voltmeter. The safest method is as follows: Connect five 110-volt incandescent lamps in series and connect one terminal of the group to the rail; next connect your voltmeter cords to the terminals of the lamp nearest the rail and then lead a wire from the undergrounded terminal of the group of lamps up to the trolley wire as shown by the accompanying diagram. Test the voltage around the single lamp and multiply it by five and you will have practically the voltage between the trolley wire and the rail. (2) Usually it makes a difference as to which way the current passes through the voltmeter, but it will only require two trials in order to get it connected up right. If it is connected wrong the needle will tend to move away from the scale; if it is connected up right the needle will move over the scale and indicate the voltage.



A NEW SERIES ALTERNATING-CURRENT ENCLOSED ARC SYSTEM.

The Western Electric Company has brought out a particularly simple series enclosed-arc system for use on alternating-current circuits, one of the features of which is that no regulating device is necessary when the lamps are operated in full series groups on a constant-potential circuit. The series of lamps can be connected directly to the mains of an alternating-current generator or supplied from the secondary of a constant-potential transformer, and the manufacturers claim that the power factor of the circuit remains constant, regardless of the number of lamps in series. Each lamp is provided with an automatic cut-out which substitutes a small choke coil in the place of the lamp when the lamp is switched out or the carbons are consumed. This choke coil consumes energy at the rate of about 35 watts.

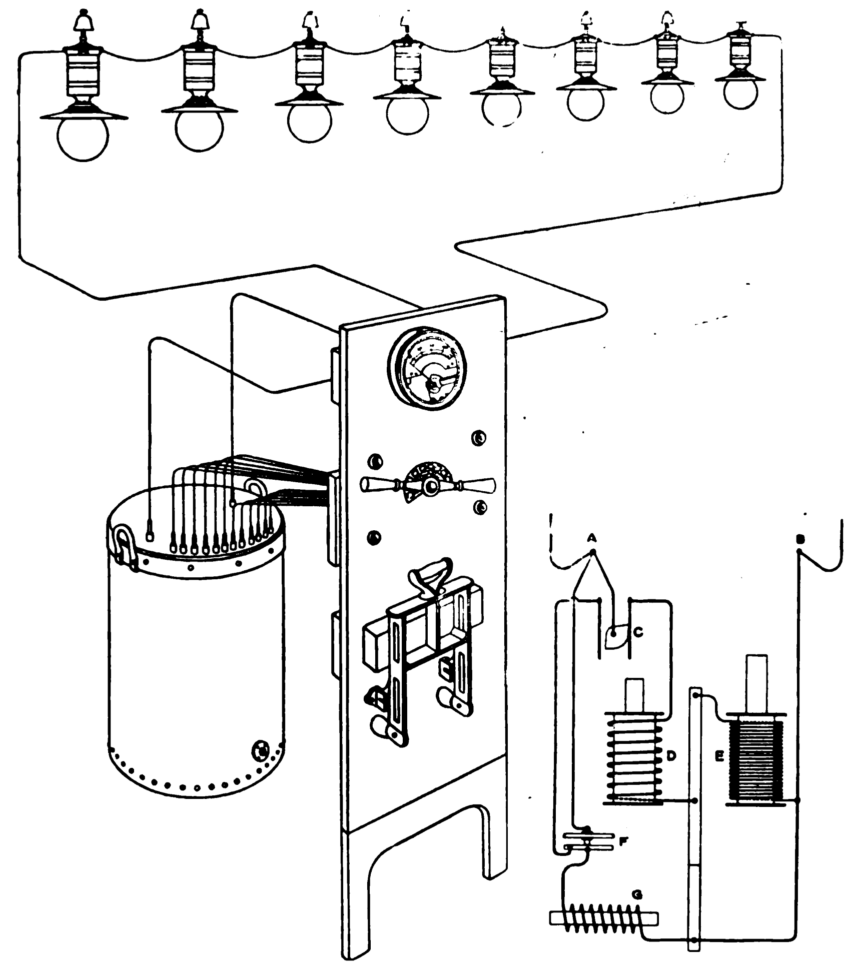


FIG. 1.—CIRCUIT DIAGRAM.

FIG. 2.—LAMP DIAGRAM.

Fig. 2 is a diagram of the lamp circuit; A and B are the lamp terminals; C is the hand switch, which connects the terminal, A, with either the series winding, D, or the choke coil, G, according to the position of the switch block; E is the shunt magnet; F is the cut-out, the contacts of which are brought together by the mechanism of the lamp when the carbons are consumed, connecting terminal, A, to the choke coil, G, regardless of the position of the switch block, C. The upper carbon is fed by a special clutch actuated directly by the main lever of the regulating mechanism, which is controlled by the solenoids, D and E; these solenoids act differentially, so that one lamp cannot rob the others of voltage. The choking coil, G, is adjustable to suit the frequency of the circuit, so that the lamp as it stands is practically universal.

The rate of consumption at the arc is 425 true watts, the normal current flow being 6.6 amperes, and with this rate of flow the carbons will burn about 90 hours with one trimming. The difference of potential at the terminals of the lamps is approximately 80 volts.

The complete system includes a constant-potential transformer, the secondary e.m.f. of which is adjustable by means of taps in the transformer winding and a dial switch, as indicated in Fig. 1. If the circuit contained exactly the proper number of lamps to take the full normal voltage of the circuit, and there were no liability to short-circuiting any of them, this transformer would not be needed, as the choke coils in the lamps themselves take care of individual extinction, as previously described. Where it is not desirable, however, to connect in the maximum number of lamps, the transformer is absolutely necessary, and in any case its use is advisable so that in the event of an accidental short-circuit of any portion of the series, the e.m.f. impressed on the remaining lamps can be adjusted at the switchboard.

A TRANSFORMER DESIGNED FOR TRIPLE SECONDARY SERVICE.

The transmission of power by electricity to any considerable distance is usually undertaken with reference to supplying a demand for power in some large city or group of cities. There can frequently be found along the line of such a transmission, however, numerous smaller cities or towns in which additional profitable customers can be found, but the amount of power that can be sold at such points is generally so small that the high cost of the small, high-voltage transformers necessary would mean too large an investment for the returns obtainable.

Power is commonly desired at such points at two or more voltages. For example, 2000 volts may be desired for house-to-house distribution for lighting, and 375 volts for supplying 500-volt railway rotary converters or motors. Suppose, for instance, 200 kilowatts is desired for the first and 400 kilowatts for the latter service on a three-phase transmission; then three transformers of 65 kilowatts output and three of 130 kilowatts output would be required. If the potential used on the transmission lines is 30,000 volts or over, these transformers must of necessity have a high cost per kilowatt. It is evident, therefore, that a very considerable saving could be accomplished and higher efficiency obtained if both the secondary voltages desired could be supplied from the secondaries of the same transformer, thus increasing the size of the units to 200 kilowatts.

The accompanying illustration shows such a transformer of which the General Electric Company has recently made a considerable number. The particular design here shown was built for the Kalamazoo Valley Electric Company, Kalamazoo, Mich., whose transmission lines start from the power house at Allegan, Mich., and stretch for more than 100 miles through the cities of Kalamazoo, Battle Creek, Jackson and intermediate towns.

The transformer conforms with the General Electric Company's standard design of oil-immersed, water-cooled transformer. The base is composed of a single heavy casting, elliptical in shape, to which is riveted the sheet-steel tank. A switching panel is mounted on one face of the tank and provides means for varying the voltages of the secondary windings. The 40,000-volt primary terminals are brought out through large porcelain bushings in the cover. The terminals of the coils used for cooling are also brought out through the top.

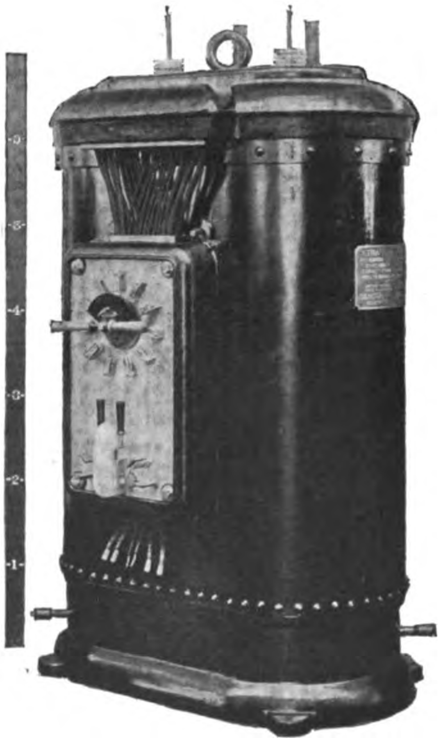
The transformers have a capacity of 225 kilowatts each. Three distinct secondary windings are provided; one for lighting distribution and two for power purposes. The secondary designed for lighting circuits has a nominal voltage of 2500, but by means of a dial switch this can be adjusted to any desired value between 2300 and 2750 volts. The other secondaries are designed for furnishing power at a nominal voltage of 385. A small range of adjustment can also be obtained on these circuits, however, by means of pivoted knife-blade switches, which are shown on the lower part of the switching panel.

One set of these secondaries is to supply current to 550-volt rotary converters for furnishing power to the various street railways that stretch along nearly the entire length of the transmission line; the other set operates 550-volt rotaries furnishing current for general distribution to 500-volt stationary motors. The latter service necessarily use ungrounded circuits, which explains why separate rotaries and secondary circuits are necessary for the two classes of service.

The capacities of the secondary windings in the groups of transformers located at different points throughout the system are differently proportioned according to the local demands. In some cases they are practically equal, while in others one class of service would require four or five times as much capacity as the other. It is thus seen that the use of the triple secondaries avoids at times the use of objectionably small units for such high-voltage transformers.

The proper distribution of the various secondary windings with reference to each other and the primary winding in such transformers is a question requiring careful consideration. Tests on these transformers showed that this feature had been so successfully worked out that no change in the load on any of the secondary circuits varied the voltage of that or any other of the secondary circuits more than 1 per cent.

The high-voltage primary and sectional secondary necessarily mean that much of the winding space must be sacrificed for insulating material. Nevertheless these transformers have 97.5 per cent efficiency. They have a rise in temperature, as determined by the increase in resistance of the coils, of less than 40 degs. C. They were subjected to an insulation test between primary and secondary of 90,000 volts alternating potential. Since being placed in service they have been subjected to lightning strains known to exceed 200,000 volts without developing any weakness.



G. E. MULTIPLE SECONDARY TRANSFORMER.

◆

GAIN IN EFFECTIVE ILLUMINATION FROM INCANDESCENT LAMPS.

The Shelby Electric Company, of Shelby, Ohio, has adopted a three-turn filament in its incandescent lamps which is claimed to result in an effective illumination of twice as many candles per watt as the ordinary forms of filament give. The double-turn filament, it is stated, distributes less than 7 c. p. directly below the lamp, when showing 16 c. p. by horizontal measurement; the new Shelby lamp is said to show 11½ c. p. below the lamp, while giving 16 c. p. horizontally.

The diagrams, Figs. 1 and 2, show the comparison made by the Shelby Company between a double-turn and a triple-turn filament. The company claims that as incandescent lamps are generally located above the line of vision and the light is used to illuminate objects that are almost always below the line of vision, the light radiated through the tipped end of the bulb becomes the useful light and, consequently, should be used as a basis for determining the efficiency of an incandescent lamp.

A test of the ordinary lamp gave the distribution of light over the top of the lamps as follows, a double-turn anchored filament lamp being used and the voltage remaining constant at 110:

	Candles
Horizontal measurement	16
15° below horizontal	15½
30° below horizontal	14¾
45° below horizontal	13
60° below horizontal	11½
75° below horizontal	7½
90° or vertical	6½

A lamp with the Shelby form of carbon (triple coil) gave the following measurements:

	Candles.
Horizontal measurement	16
15° below horizontal	16
30° below horizontal	15½
45° below horizontal	14½
60° below horizontal	13¼
75° below horizontal	12¼
90° or vertical	11½

The curves shown by Figs. 1 and 2 were plotted from these tests. The Shelby Electric Company offers to furnish copies of tests made by scientific institutions that will prove conclusively that the measurements as stated above are correct, and hence the only point to be determined is whether the light radiated perpendicularly is of great importance to the lamp user.

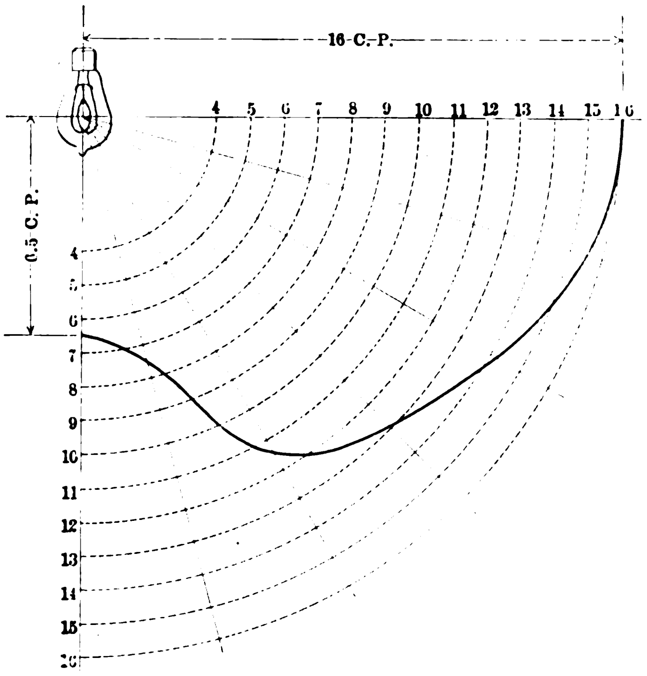


FIG. 1.—CANDLE-POWER CURVE OF DOUBLE TURN FILAMENT: TIPPED BULB.

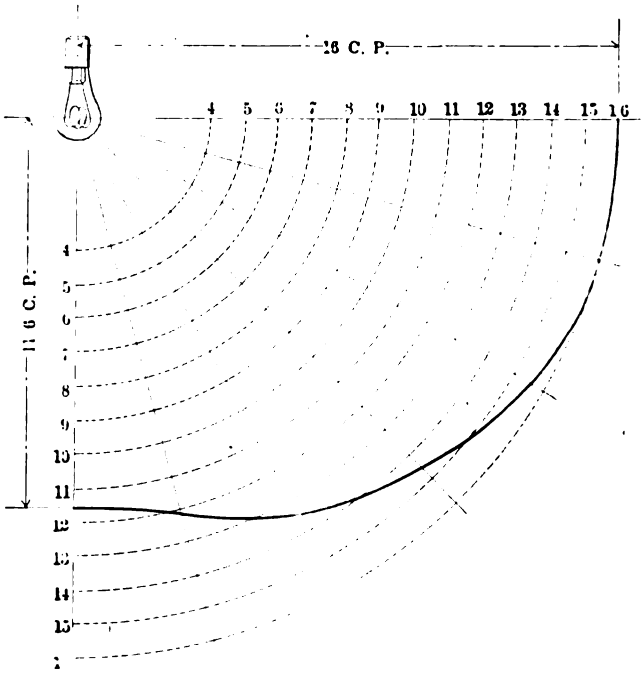


FIG. 2.—CANDLE-POWER CURVE OF TRIPLE TURN FILAMENT: TIPLESS BULB.

New Apparatus and Appliances

"G. I." SPECIAL SIGN LAMPS.

With a view to providing a water-tight fit between the base and socket of incandescent lamps used for sign work, the General Incandescent Lamp Company of Cleveland, Ohio, has brought out a new special sign lamp illustrated by Fig. 1. The main feature of this lamp is the enlargement or annular ring around the neck of the bulb, as shown in the engraving. A rubber ring or gasket placed in front of this shoulder is compressed against the edge of the socket when the lamp is put in the receptacle, thus forming a water-tight joint between them which protects the electrical contacts of the lamps and the conducting portions of the socket from moisture. The friction of the rubber against the abutting ring on the bulb and the socket also prevents the lamp from becoming loose in the receptacle. Those who have had experience with electric signs will readily recognize the advantages obtained by the use of this specially-designed bulb. While these lamps are intended especially for signs, they may be used to advantage in all out-door work, as well as for industrial purposes, as in breweries and chemical works, where dampness or corroding gases make the use of electric lamps difficult. These special lamps are made in bulbs of two sizes, the larger being shown in the cut, and is 1¾ ins. in diameter by 4 ins. over all; made in all voltages from 45 to 130, and in candle-powers from 4 to 10, inclusive. The smaller size lamp is 1½ ins. in diameter and 3 ins. in length over all, and is made in candle-powers from 2 to 6, inclusive. The recent exhibit of the letters "G. I.," fitted with these special sign lamps, at the National Light Association, Auditorium Hotel, Chicago, caused a great deal of favorable comment.

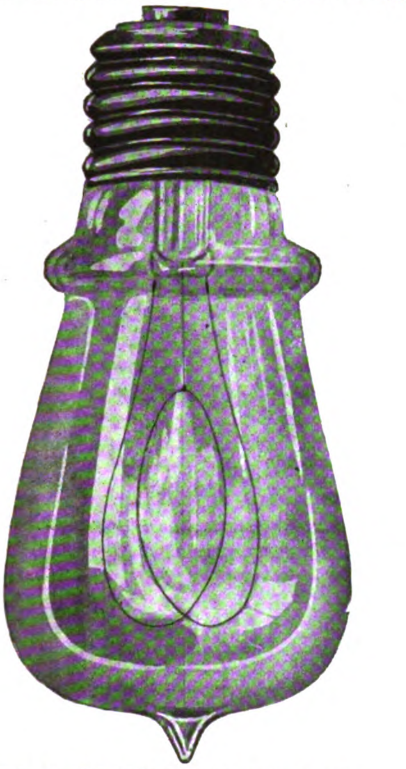


FIG. 1.—"G. I." SPECIAL SIGN LAMP.

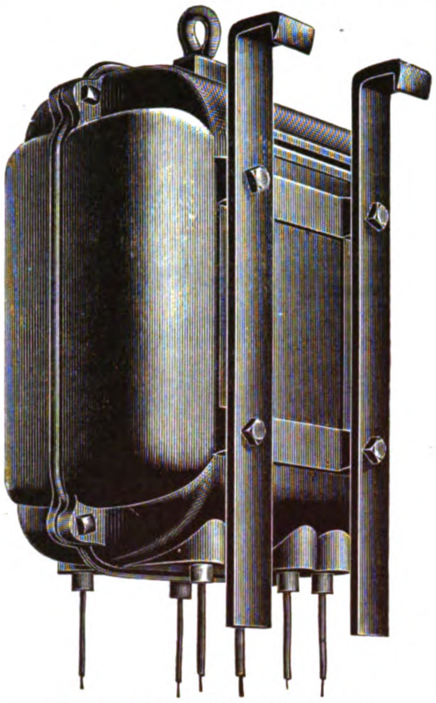


FIG. 2.—MOLONEY TRANSFORMER

MOLONEY TRANSFORMER.

Fig. 2 gives an exterior view of the latest form of Moloney transformer, which is built by the Moloney Electric Company, St. Louis, Mo. The transformer is of the core type—winding not enclosed by the core iron, and ventilated by a slot in the bottom of the case and one in the top; the latter slot is shown between the hanging straps in the engraving. It slants downward from the inside so that water cannot blow or trickle into the case. The hanging straps need no description beyond that afforded by the illustration. Two features of construction which are said to result in a particularly high degree of reliability are the compression of the core plates and the application of unusual tension to the wire during the process of winding. The object of these precautions is to get rid of core and coil vibrations, which obviously tend to deteriorate the structure. The makers also state that the iron used is of such a quality that no "ageing" can be noticed up to about 18 months of service. The transformers are provided with four primary and four secondary terminals, so that they may be connected for either 1000 or 2000 volts at the primary end and for either 50 or 100 volts at the secondary end.

THE ANTHONY BORING TOOL.

The American Electric Company, Detroit, Mich., is manufacturing the Anthony boring tool shown in the upper part of Fig. 3. This tool is designed to take the place of the old angle brace, and its superior convenience and quality of work, as compared with the old form of brace, is graphically shown by the illustration. The tool consists of a drill spindle geared to a driving spindle by bevel gears, the driving spindle being provided with an adjustable crank. The driving spindle box is mounted on a straight-edge which is parallel with the bit spindle, so that when the straight-edge is held up against the edge of the joist the bit bores a perfectly horizontal hole through the joist, as indicated by the engraving. The great advantage of having all of the holes match, as compared with having them bored at all sorts of angles, does not need any emphasis. The driving spindle can be adjusted to the straight-edge so as to bore a hole any distance above the edge of the joist within the limit of the length of the driving spindle. It is obvious that with the spindle set at any predetermined distance from the straight-edge, all holes bored through the joists will be the same distance from the lower edge, so that the wire will pull straight through. The drill chuck is made to take any standard machine bit with a ½-in. shank.

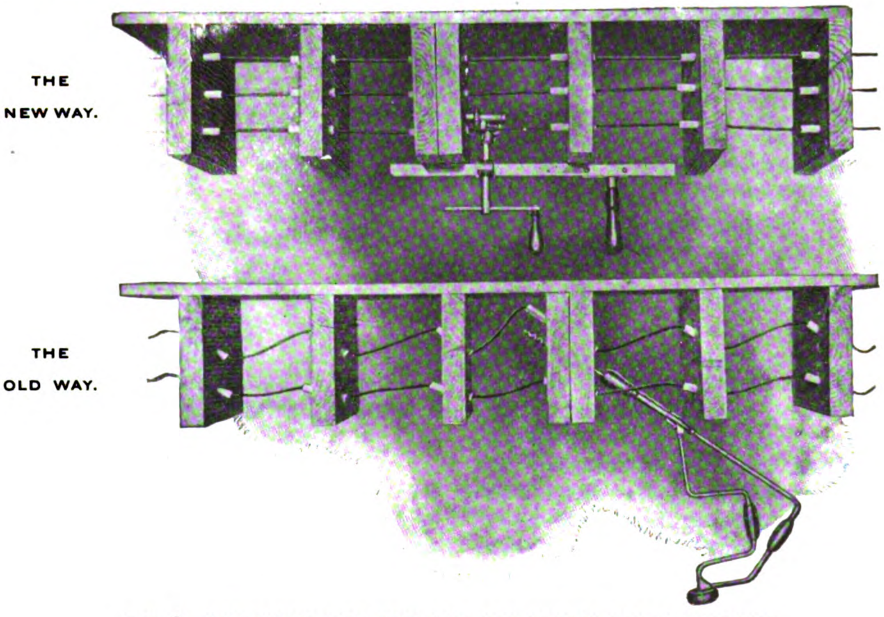


FIG. 3.—COMPARISON OF NEW AND OLD BORING TOOLS AT WORK.

ENGINES WITH REMOVABLE OIL SHIELDS.

To fulfill one of the conditions of the guarantee under which every engine built by the Skinner Engine Company of Erie, Pa., is sold, that not one particle of oil shall be thrown from the engine, and at the same time to make the engine as accessible as any open engine, avoiding all-boxed-in construction, the oil shields illustrated by Fig. 4 were designed and adopted. These shields, which consist of light iron castings, entirely surround the crank discs and completely cover the connecting-rod and guides. They are neatly finished being nickel plated and striped with the engine color. Any one of the shields can be entirely released for removal by simply loosening two thumbscrews, one of which is shown in the illustration on each side of the crank disc enclosure. A small hand plate is provided in the center disc shield through which the condition of the crank-pin may be noted while the engine is running. The shaft-journal boxes are protected by nickel plated shields which prevent the oil from following along the shaft to the wheels or armature as the case may be. An oil groove surrounds the base of the engine bed, from which a drain pipe carries to the oil and water separator any oil that may accidentally get on the sides of the engine. The engraving shows a Skinner automatic oiling engine of the belted type equipped with these shields, the wheels being left off to give a better idea of the shield construction and general appearance.

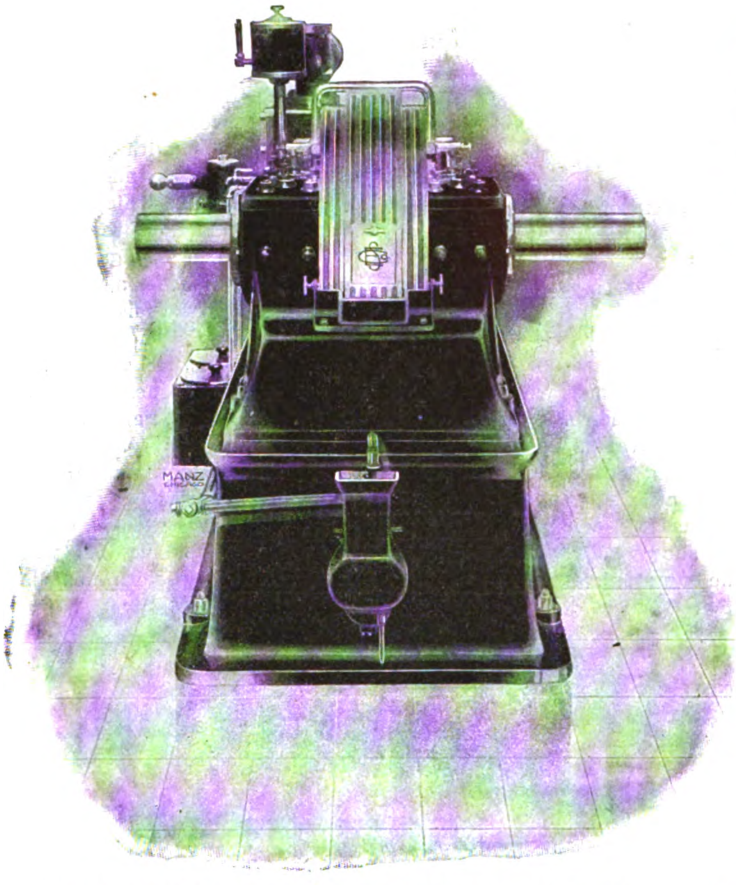


FIG. 4.—SKINNER ENGINE WITH REMOVABLE OIL SHIELDS.

"AUTOGAS" DRY BATTERY.

William Roche, New York City, has brought out a special dry battery for ignition work in connection with gasoline engines which is particularly constructed for automobile work. The cell, which is illustrated by Fig. 5, is called the "Autogas." Eight cells are set up in a neat case; four cells are in circuit and four cells in reserve are connected with a switch, so the user can cut in one of the reserve cells as needed. When all eight are used up, the cells can be taken out of the case and replaced with new ones by any intelligent boy. The case measures 12 by 6 by 9 ins. and weighs only 23 lbs. The battery is also adapted for carriage lighting, surgical and dental lamps, etc., for which classes of service it is put up in a case 9½ by 9½ by 9 ins., and weighing 26 lbs. The cells, nine in number, are connected in three series of three cells each, thus enabling the operator to use one set and have two sets in reserve. This is said to prolong the life of the three sets about 20 per cent.

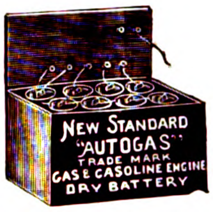


FIG. 5 —"AUTOGAS" BATTERY.

A SOCKET EXTENSION TAP.

The socket extension tap shown by Fig. 6 is marketed by the Socket Extension Tap Company, of Boston, Mass. Holes are punched in the shell of the socket by a tool furnished by the company, and porcelain bushings are inserted in these holes, which are located opposite the lamp socket terminals, as shown. By inserting the pins in the holes, connection is made with the terminals, and extra light or power for fans, etc., may thus be obtained. The pins constitute the terminals of flexible cord conductors, and are readily attached without solder or special tools. When the pins are inserted either the fixture lamp or extension, or both, may be used. This extension tap may be readily applied to all styles of shell sockets without detaching the wires, and is constructed to meet the requirements of the National Board of Fire Underwriters. Since no current-carrying parts are exposed, there is no danger of short-circuiting, or of receiving shocks while handling the tap.

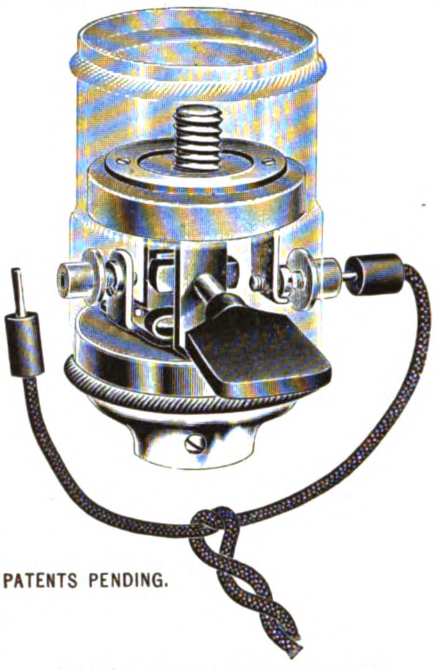


FIG. 6.—SOCKET EXTENSION TAP.

STURTEVANT VENTILATING FANS.

The electric disc fan has become established as a local cooling device for summer use, but its ability is limited to merely stirring up a breeze. For the actual movement of air to or from buildings or through ducts, a different type is required. The B. F. Sturtevant Company of Boston, Mass., is now building the type of electric-propeller ventilating fan shown by

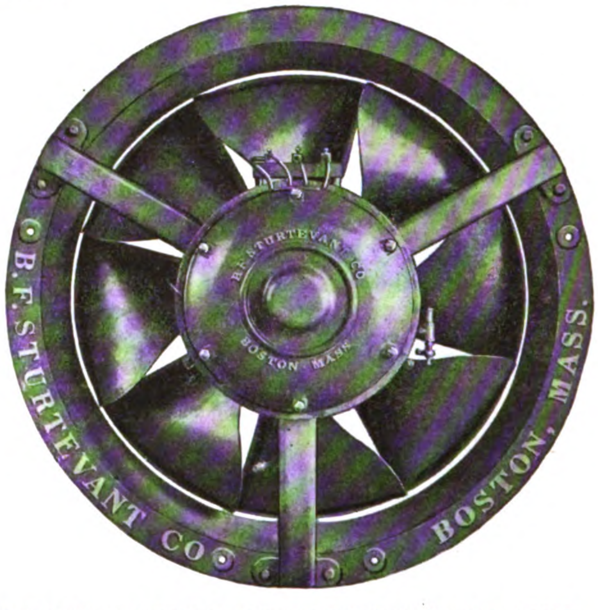


FIG. 7.—STURTEVANT ELECTRIC MOTOR AND VENTILATING FAN OUTFIT.

Fig. 7, to meet the latter requirements. The fan wheel is carefully designed to act against reasonable resistance and to move the air in lines parallel to the axis of the shaft. It is contained within a special circular frame casing which is conoidal in form, tapering toward the circumference of the wheel. This, it is said, results in decreasing the resistance offered to the entering air. The frame carries a tripod support with an annular center, within which is centered a bipolar motor having a circular field ring to which the pole pieces are attached. Extending out from either side of the field ring is a yoke which contains the ring oiler bearings. The bearings are self-aligning and self-oiling, and fitted with composition sleeves which are removable from the outer end of the boxes. Hard carbon brushes carried in holders of a modified reaction type are employed and permit of easy adjustment when it becomes necessary to reverse the direction of rotation of the motor. Special light end casing with removable centers are provided, which when applied and bolted in place entirely enclose the motor, absolutely protecting it from dust. This is a most important feature in a machine of this type where the air, possibly laden with dust, is drawn directly across it. The movement of this air is of great service in maintaining a low temperature of the surface, while the motor itself is designed with the utmost care to avoid excessive heat. This motor is said to be capable of continuous operation for 10 hours with a maximum temperature rise not over 60° F. The entire outfit is ordinarily shipped complete, and may be bolted directly to the wall over the opening through which the air is to be drawn or forced. These fans are built in sizes from 18 ins. to 120 ins. diameter, with capacities ranging from 2000 to 175,000 cub. ft. per minute; the motors ranging from 1/6 h.p. to 14 h.p.

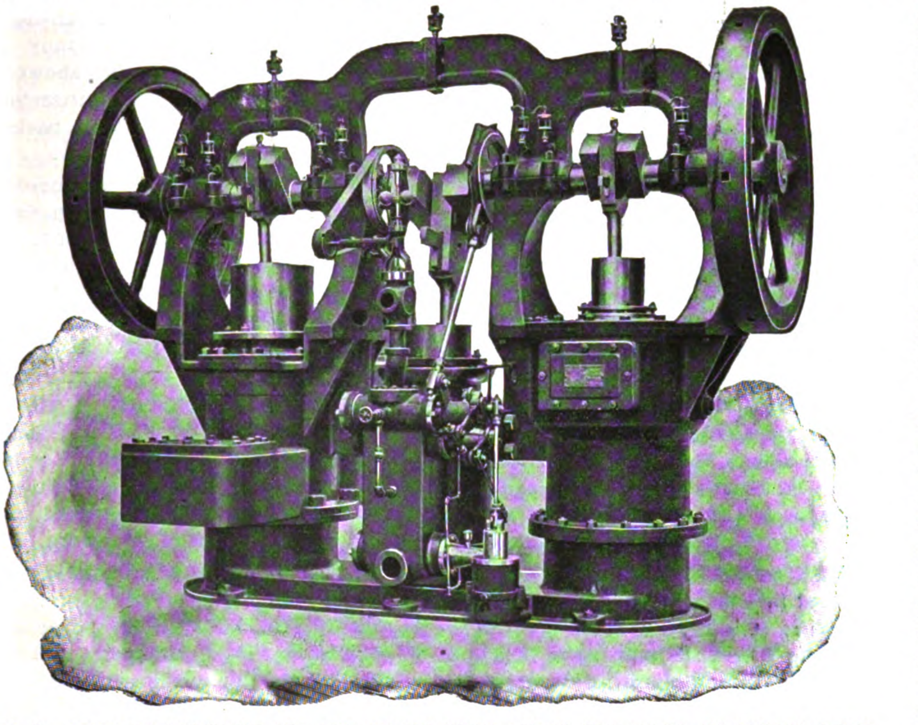


FIG. 8.—CONOVER COMBINED AIR AND CIRCULATING PUMPS DRIVEN BY SINGLE-CYLINDER COMPOUND ENGINE.

CONOVER COMBINED AIR AND CIRCULATING PUMPS.

The accompanying illustrations show a new combined air and circulating pump recently brought out by the Conover Manufacturing Company of New York. The air and circulating pumps are both very heavy in design, and being operated by a Corliss compound condensing engine, the economy naturally is of a high order. The air pump is the regular Conover patter vertical single-acting machine, and is made amply large to do its work even at the lowest number of revolutions required by the circulating pump to give the proper amount of circulating water through the surface condenser. The air pump, except for the slight difference in friction, requires practically the same power to operate it at all speeds within the working range. The same water and air being delivered in each case, a faster speed merely delivers a smaller quantity at each stroke and proportionately reduces the mean effective pressure. This arrangement therefore combines the advantages of separate air and circulating pumps and the additional advantages of requiring less attention and giving a much higher economy. The circulating pump is of the double-acting trunk-displacement type, which gives a very steady discharge and only requires one set of suction and discharge valves.

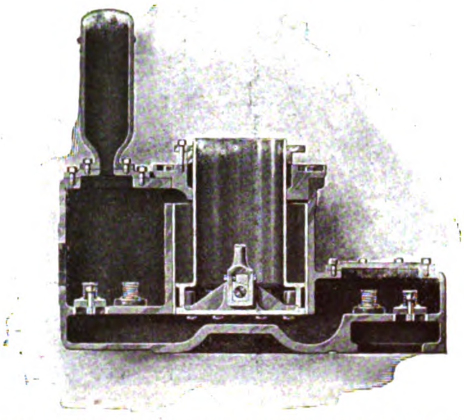


FIG. 9.—SECTION THROUGH CIRCULATING PUMP.

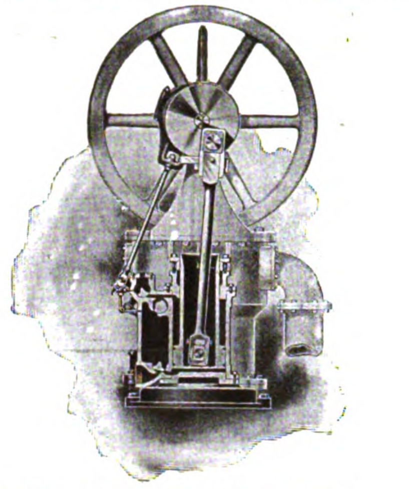


FIG. 10.—SECTION THROUGH ENGINE.

Fig. 9 is a cross-section of the circulating pump and gives a clear idea of its construction. All the internal parts, including the plunger, are made of brass. Fig. 10 is a cross section of the driving engine, which is a compound with one cylinder and only takes steam once for a full revolution; it runs condensing.

MINERAL WOOL IN POWER-HOUSE CONSTRUCTION.

In all buildings, hollow vertical flues and open spaces in walls or partitions should be completely closed and filled with some non-conducting, non-burning material, such, for instance, as mineral wool. The cheapest thing to do—and it should always be done—is to cut off all manner of communication by hollow passages from one story to the next above by so-called "fire-stops," consisting of rows of bricks laid in mortar between the furring studs of brick or stone buildings, or in the hollow spaces of the outer studs of frame structures, filling completely the whole space from the outside of the wall to the interior finish of wainscoting or baseboards.

The hollow spaces between floor-boards and the lathing and plastering of ceilings accumulate dirt and dust, and are objectionable, not merely from a sanitary point of view, but principally on account of the increased danger in case of fire. Such spaces, moreover, form the hiding-places of mice and rats, which have a taste for phosphorus and often accumulate unburnt matches; these are readily ignited by gnawing, and form the origin of many mysterious fires. To avoid this, all horizontal spaces between floor joists should be closed by completely filling in the space from the sills or girders upon which the floor joists rest to the wall. Among the materials most suitable for this purpose is mineral wool, which is peculiarly well adapted to it by reason of its fluffy structure, fireproof character and ease of application.

A GROUP OF DELEGATES TAKEN AT THE CHICAGO CONVENTION.

ELECTRIC LIGHT CONVENTION NOTES.

H. T. PAISTE, of the H. T. Paiste Co., Philadelphia, was one of the welcome visitors.

THE MOLONEY ELECTRIC COMPANY, of St. Louis, had its interests well taken care of by Mr. T. O. Moloney.

SAMUEL MANKOWITZ, Chicago, was constantly in evidence, and interested many of the attendants in his weatherproof line wire.

M. J. ISAACS, of K. McLennan & Co., was greatly missed. Mr. Isaacs usually attends the Convention, but was unavoidably detained from the last one.

F. G. BOLLES, of the Bullock Electric Manufacturing Company, came on from Cincinnati to look after the interests of his company at the Convention.

THE AMERICAN ELECTRICAL WORKS, of Providence, R. I., were ably represented by their Western manager, F. E. Donohue, assisted by E. H. Hammond.

ARTHUR O. GARRISON, vice-president The Columbia Incandescent Lamp Company, came up from St. Louis for a day or two to greet his old friends at the convention.

CHARLES BLIZARD, the popular sales manager of the Electric Storage Battery Company, would have been missed by his many friends had he not come on from Philadelphia.

CAMP CONDUITS were kept in evidence by A. L. Daniels, the New York representative of the H. B. Camp Company, of Akron. Mr. Camp was expected but was unable to attend.

THE ROYAL ELECTRIC COMPANY, Peoria, Ill., had many a good word put in for its well-known alternators and transformers by Manager G. G. Luthy, who managed to find time to attend the Convention.

B. J. ARNOLD, of the Arnold Electric Power Station Company, was indefatigable in his efforts to entertain the out-of-town visitors, who will long remember Mr. Arnold's many acts of thoughtfulness and courtesy.

A. H. PATTERSON, of the New York office, and Mr. Fox of the Chicago office, were present in the interests of the Phoenix Glass Company, manufacturers of shades and reflectors for arc, incandescent and gas lamps.

ROBERT EDWARDS, JR., brought a selection of the specialties of his firm, Edwards & Company, of New York, among which were a new type of automatic switch and time switch and a number of automobile specialties.

THE OKONITE COMPANY, in addition to the representation furnished by its western agents, the Central Electric Company, sent General Superintendent George T. Manson, who found many of his old friends on the lookout for him.

KEYSTONE INSTRUMENTS were represented at the Convention by George C. Ewing, of the New York office of the Keystone Electrical Instrument Company. Many were heard inquiring for President Stephens, who was unable to be present.

THE NEW YORK & OHIO COMPANY of Warren, Ohio, was represented by Secretary and Treasurer W. D. Packard, who had an interesting exhibit of the company's Packard lamps and transformers in the parlors of the Electric Appliance Company.

JOHN A. ROEBLING'S SONS COMPANY of Trenton, N. J., was ably represented by R. L. Shippy, A. B. Conover, Jr., and F. W. Harrington of New York; W. P. Bowman, manager of the Cleveland office; and George C. Bailey, D. Foster Ivins and W. H. Slingluf.

PRESIDENT JACOB BUNN, with Mr. Ludwig Gutmann, the electrical engineer of the Sangamo Electric Company, came up from Springfield, Ill., and showed one of the Gutmann recording wattmeters to many interested visitors at the parlors of the Electric Appliance Company.

NO BETTER "INDEX" was needed by the Illinois Insulated Wire Company than that furnished by the presence of its popular president, F. H. Alden, who was seen frequently at the Convention. He reports an exceedingly gratifying demand for the company's "Index" brand of weatherproof wire.

THE PERU ELECTRIC MANUFACTURING COMPANY, of Peru, Ind., exhibited specimens of their full line of high grade porcelain electrical specialties, including the "Pemco," a new rosette, especially adapted for moulding work. President R. H. Bouslog was in charge of the exhibit.

JOSEPH M. HILL, general manager of the Electric Vehicle Company, and one of the most popular members of the electrical fraternity, was present with his wife. The rapidly-increasing popularity of his company's automobiles is due, in no small degree, to Mr. Hill's unremitting labors in the company's interests.

SACHS-NOARK FUSES were exhibited by the H. W. Johns Manufacturing Company of New York. The company also showed a line of asbestos electrical fittings and pipe covering. Among the representatives present were T. G. Younglove, Chicago manager, and Joseph Sachs and E. H. Younglove of New York.

THE WAGNER ELECTRIC MANUFACTURING COMPANY, of St. Louis, was represented by Assistant General Manager W. A. Layman, who found many of his old friends waiting to greet him. Many inquiries were heard for the company's general sales manager, E. H. Abadie, who was unable to be present.

THE ELECTRIC APPLIANCE COMPANY of Chicago entertained many visitors at its parlors, where it had some very interesting advertising literature devoted to the many specialties for which this company is the agent. President W. W. Low and Secretary T. I. Stacey attended the Convention several times.

THE ELECTRIC GAS LIGHTING COMPANY, of Boston, was fortunate in having its manager, H. C. Thomson, present at the Convention. The company has prospered exceedingly under his able management, and his Western visit will undoubtedly result in a speedy increase in the company's business from that section.

PASS & SEYMOUR, of Syracuse, N. Y., sent their manager, B. E. Salisbury, to look after their interests. Although the porcelain specialties of this firm are so widely and favorably known, Mr. Salisbury believes in "keeping everlastingly at it," and the results of his policy are shown in the company's steadily increasing business.

"CLING-SURFACE," the well-known belt dressing of the Cling-Surface Manufacturing Company of Buffalo, N. Y., had its interests well taken care of by W. N. Matthews, who came up from St. Louis in the interests of this specialty, and also the Stombaugh land anchor, for electric light and telephone pole work.

THE CUTTER ELECTRICAL MANUFACTURING COMPANY, of Philadelphia, was fortunate in having its president, Mr. Henry Cutter, at the Convention. One would look for a long time for a more popular and affable member of the electrical fraternity, or one who takes greater delight in looking after the pleasure of his friends.

G. E. VARNEY came up from Indianapolis to see his many friends. His new enterprise, The Varney Electrical Supply Company, is prospering exceedingly. During his long connection with the old firm of Varney & McOuat, Mr. Varney made a host of friends in the electrical fraternity who will undoubtedly turn many good orders his way.

"CIRCULAR LOOM" was kept in evidence by H. B. Kirkland, manager of the New York office, and J. W. Patterson, manager of the Chicago office of the American Circular Loom Company, of Chelsea, Mass. This flexible conduit has been approved by all the official boards of inspectors throughout the country, and has had a large sale.

THE WARREN ELECTRIC MANUFACTURING COMPANY of Sandusky, which has recently placed several of its large alternators in the new electric plant of Armour & Co. of Chicago, was represented by J. Holt Gates, who took several parties of interested visitors to the Armour Works to show his company's apparatus in operation.

THE CUTLER-HAMMER MANUFACTURING COMPANY, of Milwaukee, Wisconsin, was represented by President F. R. Bacon, who reports that its business is booming, showing an increase of over 100 per cent in the month of May over the same month last year. The company distributed an attractive souvenir of colored glass for viewing the recent eclipse.

THE DIAMOND METER COMPANY, of Peoria, Ill., was represented by Secretary and Treasurer A. B. Fink, and the company's engineer, G. A. Scheeffer, who took pleasure in explaining the various merits of the Scheeffer recording wattmeter to many of the central-station men, among whom the company's meter system has met with great favor in recent years.

THE STANDARD PAINT COMPANY of New York, manufacturers of the well-known "P. & B." products, entertained many visitors at their parlors and distributed one of the handsomest souvenirs seen at the Convention, a combined card case, memorandum book and bill case. The company was represented by Western Manager J. C. Shainwald, assisted by J. F. Hicks.

THE CROUSE-HINDS ELECTRIC COMPANY, of Syracuse, N. Y., was represented by J. W. Brooks, of Chicago. The handsome switches of this company were much admired by visitors to the Armour plant. The switchboard in this establishment is one of the handsomest ever installed in the West, and the Crouse-Hinds switches upon it represent the company's usual high standard of workmanship and efficiency.

E. WARD WILKINS, of Partrick, Carter & Wilkins, Philadelphia, well known as the oldest electrical supply house in the country, attended the Convention. It is very difficult to find a hotel or any large building throughout the country where annunciators of this company are not in use. The firm has been particularly successful with its patent needle bell hotel annunciator.

A. I. WARREN, of the Warren Manufacturing Company, found time to visit the Convention. The company has recently published a well-printed folder describing the use and merits of its pulley cover. In this folder it is claimed that by applying the company's pulley cover to a metal pulley the latter acquires a leather-like surface which has natural adhesion for belting and entirely overcomes the natural tendency of belts to slip or creep on pulleys not so treated.

THE WARREN ELECTRIC & SPECIALTY COMPANY, Warren, Ohio, was represented by Secretary E. W. Gillmer, and T. S. Lane, who made many new friends for the Peerless lamps, transformers and fans, manufactured by this company. The parlor of the Illinois Electric Company, their Western agents, were constantly crowded with interested visitors. The company distributed some very attractive advertising literature.

THE CENTRAL ELECTRIC COMPANY received many visitors at their establishment, where special preparations were made for their entertainment by President George A. McKinlock and Secretary Charles E. Brown, both of whom found time to attend the convention frequently. The company detailed a large staff of gentlemen from its various departments who spared no efforts to contribute to the pleasure of the out-of-town attendants.

THE SPRAGUE ELECTRIC COMPANY had a number of its new model Lundell fans in operation throughout the Auditorium, and also displayed its new Greenfield flexible steel armored conductors, which are particularly adapted for wiring finished buildings, as well as for open construction. The company had the following representatives present: E. B. Kittle, manager of the Chicago office; J. Arthur Jones, F. S. Wilhart, E. B. Phillips, R. J. Sharpe and F. Elliptt.

THE KENTUCY ELECTRICAL COMPANY, of Owensboro, Ky., had a worthy "blue grass" representative at the Convention in the person of its general manager, A. H. Kreitler, who showed many of the delegates that the Kentucky incandescent lamp was one of the many good things for which his State is deservedly famous. Mr. Kreitler has been so successful in the lamp business that his company is going into motor manufacture, and is now increasing its factory facilities to take care of this branch of the business.

ROGER SCUDDER, general manager of the Western Electrical Supply Company of St. Louis, was in Chicago during the Convention and dropped in at the Auditorium to see his friends. Many inquiries were heard for Secretary H. K. Gilman, who was unable to be present. That this company's supply business is so rapidly increasing is due largely to the energetic business methods of Messrs. Gilman and Scudder, who see that their lines are so well stocked up that they can take care of any order, no matter how large, in the shortest possible time.

BELDEN ARC LAMPS, of the Belden-Larwill Electric & Manufacturing Company, Fort Wayne, Ind., were exhibited in a commodious parlor where the company entertained many interested visitors. This company, while comparatively new in the electrical field, has brought its lamps to the favorable attention of many of the central-station men, and reports a rapidly increasing demand for its product, which, it is claimed, has given entire satisfaction wherever the lamps have been installed. The company was represented by Messrs. Belden and Larwill and several other members of their staff.

THE ELECTRICAL APPLIANCE COMPANY, New York, distributed some interesting literature regarding its gravity motor controller. A saving of from 35 to 75 per cent is claimed for this controller over ordinary hand rheostats. Moreover, it is extremely simple and durable. Manager G. A. Nisbet was present in the interests of the company, whose devices are now being used in connection with belted electric elevators by the Western Electric Company, Crocker-Wheeler Company, C & C Electric Company and many others. The company's New England agents are S. B. Condit, Jr., & Co.

THE WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY had a large number of representatives at the convention, among whom were B. Harding, C. F. Scott, B. G. Lamme and R. S. Feicht, of Pittsburg; C. G. Burton, T. P. Gaylord, C. W. Regeston, W. R. Pinckard, Ervin Dryer, J. J. Gibson, W. S. Rugg, A. Hartwell and Fred Nelson, of Chicago; H. K. Archbold and R. D. Mershon, of New York; Calvert Townley, Boston; G. Pantaleoni, St. Louis; C. B. Humphrey, Cincinnati; T. J. McGill, Minneapolis; C. F. Medbury, Detroit, and T. A. Hall, Omaha.

THE GENERAL INCANDESCENT ARC LIGHT COMPANY, of New York, had an interesting exhibit, including Paragon fan motors, power motors, G. I. circuit breakers, Wright discount meters, rheostats, motor starting boxes, arc and incandescent lamps, switches, etc. The company also showed a new patent sign lamp which makes a perfectly tight joint when inserted in the socket. This specialty attracted much interest. Among those present in the interests of this company were Samuel Insull, Chicago; Martin J. Insull, New York; Joseph Insull, Cleveland; Frederick Raymond, Chicago, and Thomas James, Milwaukee.

THE GENERAL ELECTRIC COMPANY received many visitors at its headquarters in the large south parlor on the first floor. Among those present in the company's interests were J. R. Lovejoy, general manager of the lighting, railway and supply department; W. L. R. Emmett, engineer of the lighting department; E. H. Mullin, manager of the advertising department; Messrs. Wagoner, Reist and Hillman, of Schenectady; B. E. Sunny, manager of the Chicago office; A. D. Paige, manager sales department of the Harrison Lamp Works; W. S. Hayes, manager of the Cincinnati office; and Messrs. Beram, of New York, Hanley and Dowd of Cincinnati, Ruddy of Philadelphia, Bullen of Boston, Bull, Scribner and Boyes of Chicago.

THE HELIOS-UPTON COMPANY exhibited a storage battery of 60 cells connected up for the operation of direct-current enclosed arc lamps, of three, four and six amperes consumption. This battery was delivered complete from the company's Chicago works. The weight of each cell was 16 pounds with normal capacity per cell of 86 ampere-hours, and with the high rate of discharge of 25 amperes for a period of three hours without any fall of potential. The company also displayed a line of its direct and constant current arc lamps, including a new alternating current lamp, which, it is claimed, has fewer working parts, and is simpler in construction than any arc lamp heretofore placed on the market. It is adjustable for any alternations and standard secondary currents. The company was represented by Wm. Hood, general sales agent; K. Upton, of Salem, Mass.; Thomas Spencer, of Philadelphia, and G. H. Stout, of Chicago.

THE BRYAN-MARSH COMPANY, New York, exhibited a new form of electric sign, which was strikingly in evidence. It was made of reflector lamps, each having the appearance of a miniature searchlight, and owing to the absence of side light—the light all being thrown to the front—the sign was especially distinct; this effect could not have been obtained with regular 50 candle-power lamps owing to the side light. The reflector lamps were all 16 candle-power. The sign is not recommended except where the observer is some distance away. The company also exhibited, in addition to a full line of their incandescent lamps, both portable and station types of photometers. Two lamp manufacturers placed orders for these photometers, which should speak sufficiently of the merits of the same. The company was represented by Converse D. Marsh, president; Guy V. Williams, Northwestern representative, and E. M. Jones, Chicago representative.

THE WESTERN ELECTRIC COMPANY'S exhibit of enclosed alternating-current series arc lamps attracted much interest. The lamps are of the differential type, and work with an average pressure of 78 volts at terminals of the lamps. They draw a uniform even arc, and hardly rise in voltage at a feeding point. Indeed, these lamps were never seen to flicker or give any trouble whatever, a feature which was highly spoken of during the convention. The regulation is automatic, the choke coil being placed in the circuit by an automatic cut-out in case of a failure of the lamp to work properly, or when the carbons are consumed. These lamps were shown to work on an extremely wide variation of line voltage. The voltage was varied during the exhibition from 400 to 550 volts, the lamps adjusting their voltage accordingly and working very satisfactorily. The same lamp is used for all commercial frequencies. C. D. Crandall, manager, and A. L. Tucker, general sales agent, attended the Convention and entertained many visitors at the company's great establishment.

THE NEW ENCLOSED ARC CARBON of the United States Carbon Company, Cleveland, Ohio, was one of the most interesting of the new specialties shown at the Convention. This carbon is claimed by the manufacturers to be the equal in every respect of any foreign carbon, and aroused much interest among the lamp manufacturers and central-station men present at the Convention, forming one of the most prominent subjects for conversation in the exhibition rooms, corridors and hotel lobby. To show the carbon in actual operation several of the arc lamp manufacturers consented to its use in their lamps which were on exhibition in the hotel, and the results so thoroughly justified the strong claims made for the carbon by the manufacturers, that the United States carbon was adopted and burned in several different makes of lamps during their entire exhibit, and caused much favorable comment among those who observed its working. All station managers will see the great value of these tests and have long realized the importance of a domestic high-grade, enclosed arc carbon and the great aid it will be to the rapid development and adoption of enclosed arc lighting. Cecil L. Saunders, vice-president of the company, took charge of its exhibit in one of the rooms near the Convention Hall, and had many calls from lamp and central-station men which resulted in some very satisfactory orders. The company distributed an attractive celluloid card giving the 1900 moonlight schedule on one side and the prices of its various styles of carbons on the other.

THE MANHATTAN GENERAL CONSTRUCTION COMPANY, of Newark, had a most interesting exhibit of its arc lamps in front of the Auditorium. The company had placed in the basement of the hotel a 50-kw., two-phase, 1100-volt, 60-cycle alternator, which was driven by a direct-current motor. This alternator supplied two circuits of series alternating lamps, one of 12 lamps in a parlor occupied by the company's exhibit and another of 10 lamps on the hotel's regular arc-light standards in the street. The former circuit also contained incandescent lamps and instruments to show the constancy of the current obtained by the regulator when the arcs were cut in or short-circuited. To connect up these circuits required 2000 ft. of lead-covered wire. In addition to the two regulators in use on these two lines, the company showed a number of its standard sizes of the latest type, ranging in capacity from 12 to 100 lamps. The lamps shown in operation were of the latest type, with shunt regulating coils and no series coils whatever. The shunt coil is concentric with the carbon holder, and a dash pot, also concentric, is provided to prevent the shunt coil from striking the arc too suddenly, the dash-pot cylinder being cut away so that over the normal range of operation, once the arc is formed, there is no retardation or friction. The cut-out is electro-mechanical, the regulating magnet, when it drops the clutch to its lowest limit, closing a by-pass around the arc, but through a magnet which holds the contact closed. With the shunt magnet regulator used in this lamp, the power factor is improved over that of the series lamp, and, if desirable, the candle-power of the lamps may be changed by simply varying the current, the arcs in this case remaining of constant voltage and not closing up as they do in the differential form. The company's interests were looked after by General Manager S. Marsh Young, Max Harris, sales agent, and Messrs. Boker & Merrill.

Notes from the Telephone Convention.

W. M. SMITH of the Chicago Insulated Wire Company, Chicago, looked after the interests of his company at the Convention.

THE HOLTZER-CABOT ELECTRIC COMPANY of Brookline, Mass., had its western manager, E. R. Harding, on from Chicago.

THE NORTON TOOL COMPANY was represented by Secretary W. E. Green, and showed samples of steel-forged three-bolt clamps and cable hangers of different patterns.

THE AMERICAN CLAY MANUFACTURING COMPANY, Akron, Ohio, was represented by Mr. Harry Thompson, who incidentally took a few orders to keep his hand in.

THE NATIONAL CARBON COMPANY, Cleveland, was represented by N. C. Cotabish, M. M. Moffett and E. J. Climo, who showed a line of the company's well-known batteries and carbon specialties.

THE WILLIAMS-ABBOTT ELECTRIC COMPANY, Cleveland, had a very interesting exhibit showing its new desk set, and new model repeating coil. The well-known "Sands Special" was, of course, on exhibition.

THE KEELYN TELEPHONE MANUFACTURING COMPANY, Chicago, exhibited in the Colonial Hotel a line of its lightning arresters, bridge, series and express telephones. James E. Keelyn, the general sales agent, was in charge.

THE EUREKA ELECTRIC COMPANY, Chicago, had an exhibit of switchboards and various kinds of telephone instruments, also the Taylor cable terminal. The company was represented by I. J. Kusel, G. D. Pratt, W. R. Shaw and H. J. Kusel.

EXHIBIT OF THE NORTH ELECTRIC COMPANY.

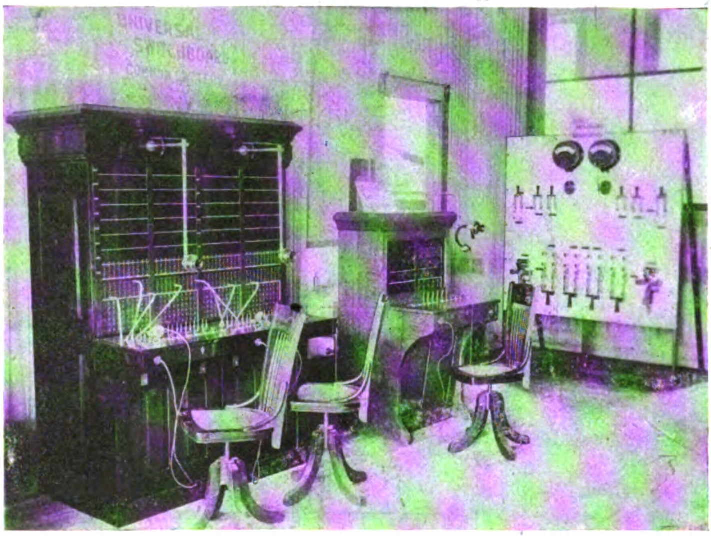


EXHIBIT OF THE KELLOGG SWITCHBOARD & SUPPLY COMPANY.

THE MOON MANUFACTURING COMPANY, Chicago, was represented by General Manager H. E. Procunier, who, it is said, closed a number of good orders for the company's well-known terminal heads.

PRESIDENT J. S. CUMING of the Central Telephone & Electric Company, St. Louis, attended the Convention. This company keeps a very large stock on hand and prides itself on its ability to fill all orders promptly.

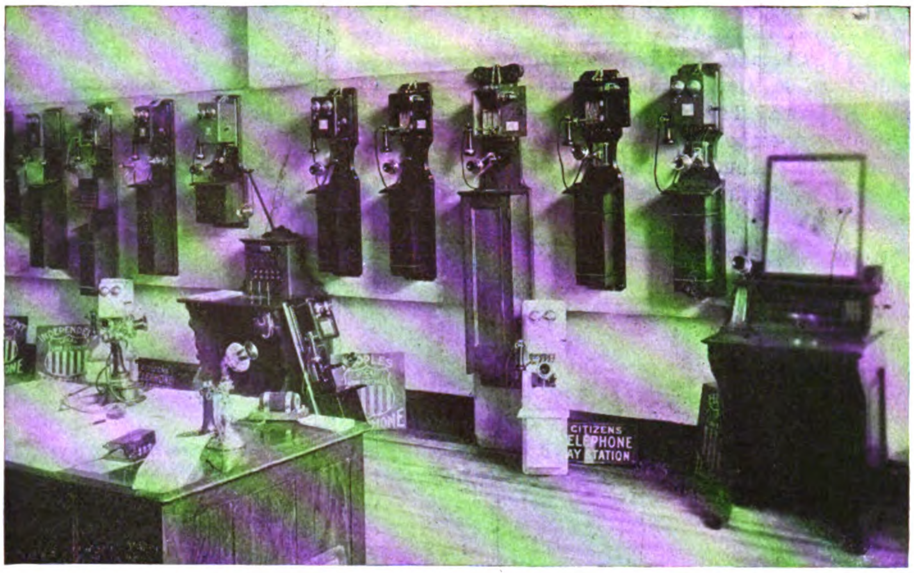


EXHIBIT OF THE AMERICAN ELECTRIC TELEPHONE COMPANY.

THE AMERICAN ELECTRIC FUSE COMPANY, Chicago, sent George Conover to the Convention, where he exhibited a line of this company's well-known electrical specialties, including lightning arresters and fuses. Mr. Conover distributed a neat aluminum stamp case as a souvenir.

THE ELECTRICAL CONSTRUCTION SUPPLY COMPANY, of Springfield, Ohio, was represented by Mr. Rodgers, who brought along with him a panel board showing a variety of pins and brackets, especially adapted for telephone work.

AMERICAN ELECTRIC TELEPHONE COMPANY, Chicago, made an attractive exhibit, and on the very first day of the Convention the company closed a contract for 2200 instruments, and before the end of the week had sold nearly every piece of apparatus on exhibition, including a 100-drop switchboard.

THE FARR TELEPHONE & CONSTRUCTION SUPPLY COMPANY, Chicago, exhibited its bridging toll-line instruments, together with an attractive display of telephone supplies. Its switchboard generator, capable of ringing through 70,000 ohms, and giving sufficient current to light an incandescent lamp, attracted much attention. President Charles W. Farr was in charge, assisted by E. W. Hurst.

THE NATIONAL INDIA RUBBER COMPANY, Bristol, R. I., made a very neat display of rubber-covered wires and cables; also hard-rubber tubing. Its popular representative, P. F. Lyons, was on hand all the time, renewing old acquaintances and making new ones, and succeeded in getting some very good orders.

THE CONSUMERS' RUBBER COMPANY of Cleveland, Ohio, exhibited a line of its goods in Room 209, with the Nungesser Electric Battery Company, and the Williams-Abbott Electric Company, their display being in charge of S. R. Driffield. This exhibit consisted of mica in various forms, such as rings, discs, sheet, etc.

SWEDISH-AMERICAN TELEPHONE COMPANY, Chicago, was represented by President E. E. Overshiner, assisted by Mr. W. R. Lowe. The company exhibited a switchboard embodying central energy and composite system, and also showed an extensive line of telephone instruments in various finishes and patterns.

THE STROMBERG-CARLSON TELEPHONE MANUFACTURING COMPANY, Chicago, did not make an exhibit of instruments, but "Central Energy" was very much in evidence, and the excellent cigars in "Goldbug" and "Free Silver" wrappers were much enjoyed. Mr. Stromberg and Mr. Henry Shafer were present during the Convention, and it was understood that they carried some heavy contracts home with them.

EXHIBIT OF THE STERLING ELECTRIC COMPANY.

ROBERT L. McOUAT, successor to Messrs. Varney & McOuat, Indianapolis, was one of the busiest men at the Convention. Mr. McOuat was accompanied by his staff of salesmen, and it was very noticeable that not a little business and the foundation for much more was consummated at "The Scouts'" headquarters. This company is one of the best known in the electrical-supply trade throughout the Middle States.

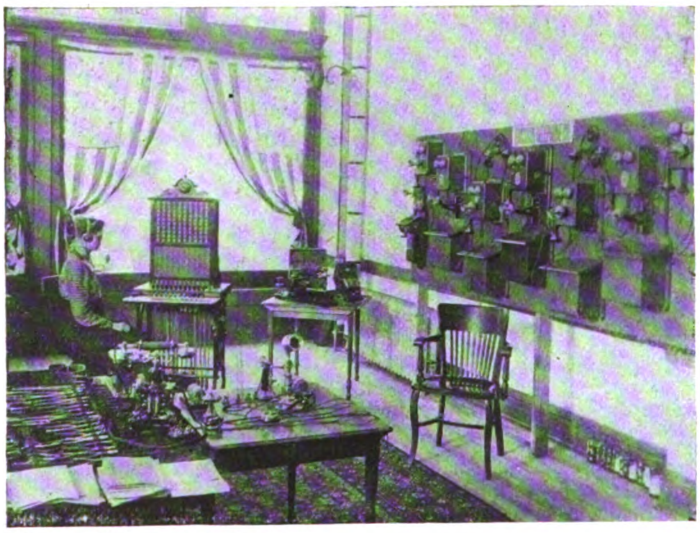


EXHIBIT OF THE ERICSSON TELEPHONE COMPANY.

EXHIBIT OF THE SWEDISH-AMERICAN TELEPHONE COMPANY.

THE WESTERN TELEPHONE CONSTRUCTION COMPANY, Chicago, was represented by General Manager L. G. Bowman and W. P. Booth, and exhibited a full line of telephone exchange apparatus and some special switchboards for toll-line use which attracted much attention from the delegates. This company has been recently entirely reorganized and while it intends to manufacture all the well-known "Western" products it has a number of improvements and additions which it will bring out in the next few weeks.

THE NUNGESSER ELECTRIC BATTERY COMPANY of Cleveland, whose exhibit was in charge of Mr. P. P. Nungesser, attracted much attention among the many consumers of battery power. The delegates were especially interested in the superior merits of the 1900 dry battery which this company manufactures expressly for telephone exchange service. Its line of closed-circuit batteries for switchboard service and central energy systems was especially interesting to the many users of this form of battery.

THE AMERICAN VITRIFIED CONDUIT COMPANY, of New York, well known in the manufacturing and contracting line for underground subway systems, were represented by their engineer, Mr. Frank L. Packard, and showed a tastefully arranged display of a full line of single and multiple duct conduits. Two contracts alone last year, aggregating six and one-half million duct feet, is a proof of the high standing and factory capacity of this concern.

THE M'DERMID MANUFACTURING COMPANY, Chicago, while not making any exhibit at the Convention other than in the person of that genial fellow, Mr. Charles L. Burlingham, succeeded sufficiently in impressing the many delegates to the extent that they are now all aware

American Electrician.

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LARGEST ISOLATED PLANT OF INDUCTION MOTORS IN THE WORLD.

THE POLYPHASE POWER DISTRIBUTING SYSTEM OF THE DEERING HARVESTER COMPANY.

An isolated electric power plant, unique both on account of its size and its use of induction motors on a large scale, is to be found in the extensive works of the Deering Harvester Company in Chicago. The great factory of this company is situated on the north branch of the Chicago River, extending north from Fullerton Avenue, and is familiar to all who travel often out of Chicago on the Chicago & Northwestern Railroad. Its factory buildings occupy 85 acres, housing 7000 employees, and contain machinery absorbing about 7500 horse-power.

The business of this factory is conducted by a great many different departments such as Extras and Supplies, Printing, Stock, General machine, Special machine, Knife, Bar, Punch, Forge, Shipping, Building and Repair, Lumber, Wood-Working, Power and Electrical, Gray Iron, Malleable Iron, Twine Manufacture, Corn, Binder, Mower, Rake, Experimental, Pattern, Tool, Knotter, Canvas, Paint, etc. The company has a local telephone system of 80 telephones full copper metallic service and central exchange, for intercommunication between these different departments. The company also has its own fire department and watch and signal services.

Up to the beginning of 1898 the power used in this plant for manufacturing was largely transmitted mechanically by means of shafts and belts from many

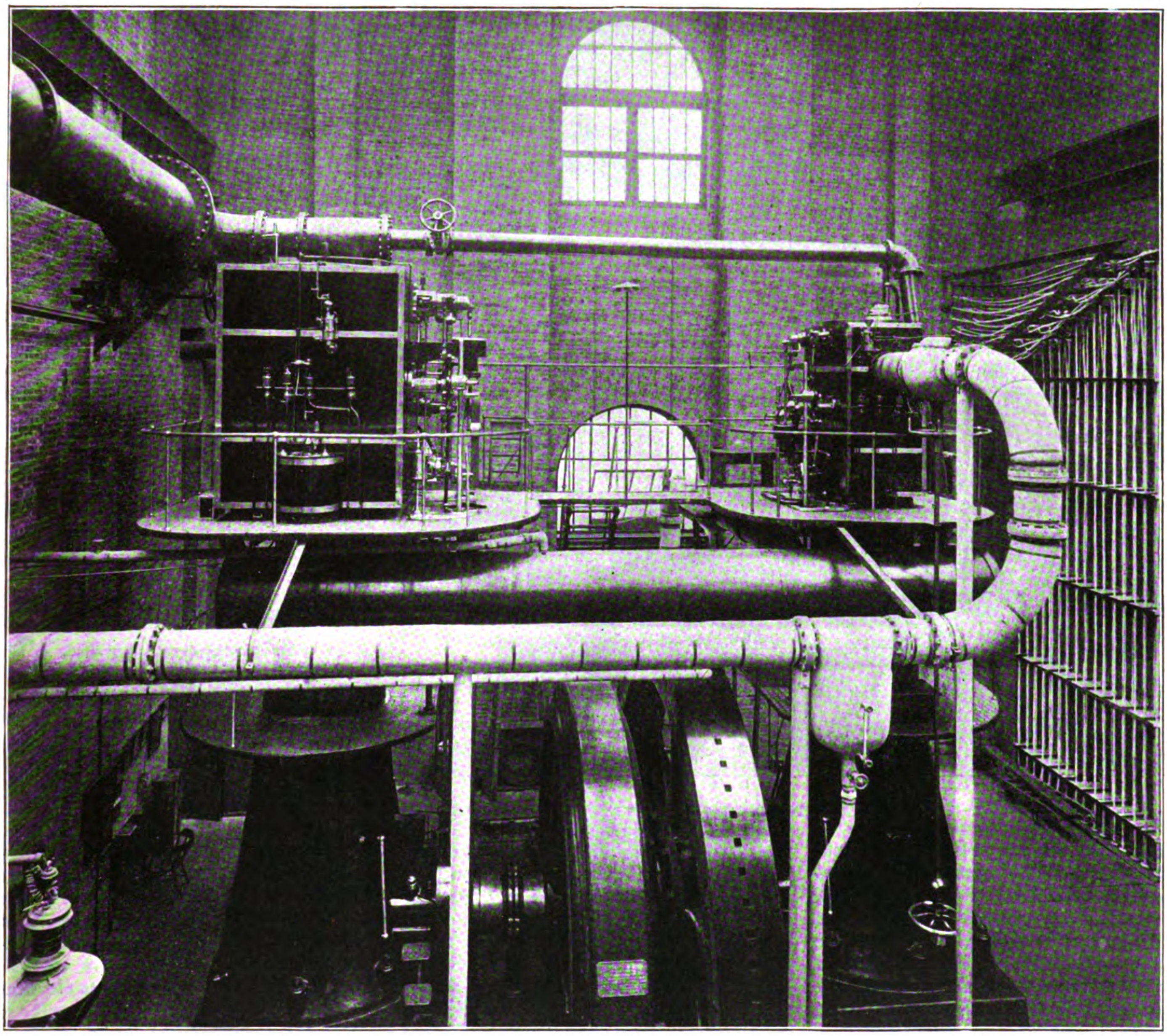


FIG. 1.—ONE OF THE 1100-KW. GENERATING UNITS COMPRISING A CROSS-COMPOUND ENGINE AND A THREE-PHASE ALTERNATOR.

steam engines scattered throughout the works. The factory at that time contained a large twine mill driven, as were all textile establishments of recent times, by a large Corliss engine, transmitting its power through a main belt, main shaft, and branch belts to the line shafting of the different floors. The twine mill was extended during the winter of '97-'98, becoming so large that the losses of a mechanical drive would prove excessive. An electric drive was considered, but the primary consideration in a plant of this kind is fire risk. There was not on the market at that time as complete and perfect a line of enclosed direct-current motors as there is at present. The starter of the direct-current motor was considered objectionable among such inflammatory surroundings as those of twine works. For these reasons a polyphase alternating-current system was considered, and with the strong assurances of its successful operation given by the General Electric Company to meet the needs and ideas of the Deering Company, it was finally adopted.

A 1000-h.p. cross-compound horizontal Corliss engine was installed in the twine works power house, direct coupled to a 750-kw. three-phase alternator, the output of which was carried to induction motors scattered through the extensions of the twine mill and the adjacent foundry. This plant was started in March, 1898, and its operation has been so successful and satisfactory that a general system of power distribution on exactly the same lines, with added improvements, has gradually been extended throughout the entire works, with an equipment of induction motors aggregating at present about 4000 horse-power, and with the addition of some 1000 horse-power more already planned. With the completion of this system but a comparatively small amount of apparatus in the entire factory will be mechanically driven without electrical transmission between the prime mover and the power-consuming devices. The respective engine capacity will be, mechanical 2000 horse-power, electrical 7500 horse-power, one 2000-h.p. generator engine being held in reserve for the present.

The application of motors throughout this factory differs considerably from the usual application of direct-current motors in machine shops in that there are no direct-connected or direct-geared motors, and practically no individual application of motors to machines, the motors in all cases driving line shafting by which the power is distributed from one motor to several or many machines. In some cases the motor armature is directly coupled to the line shaft. By this means larger motors are used than can be used when there is much individual work, higher motor speeds are made available by the belt reduction, and the load factor on each motor is better than if the motors drove individual machines or tools. Naturally this makes the attainment of successful operation much easier than with many small and variably loaded individual motors direct-geared, which, it is hardly necessary to state, would be difficult to install and operate economically from alternating circuits in the present state of art.

The electric transmission, as applied at the Deering Harvester Works, is simply a substitution for the main belt and the main shaft from the engine to the mill or shop, the distributing line shafts and belts to the machines being retained, but divided up into sections. The losses and disadvantages of this method of transmission, however, are not entirely chargeable to the alternating-current system in comparison with a direct-current system, as it seems to have been impractical to use individual motors to a very large extent on the small machines scattered throughout these works.

The frequency adopted for this plant, as well as for many similar installations for which the electrical machinery was furnished by the same builders, is 40 cycles per second, which gives a convenient number of poles and an economical speed for the sizes of motors used in this work. These sizes run from 20 to 100 horse-power, the smaller motors having six poles and having therefore a synchronous speed of 800 r.p.m., the larger mo-

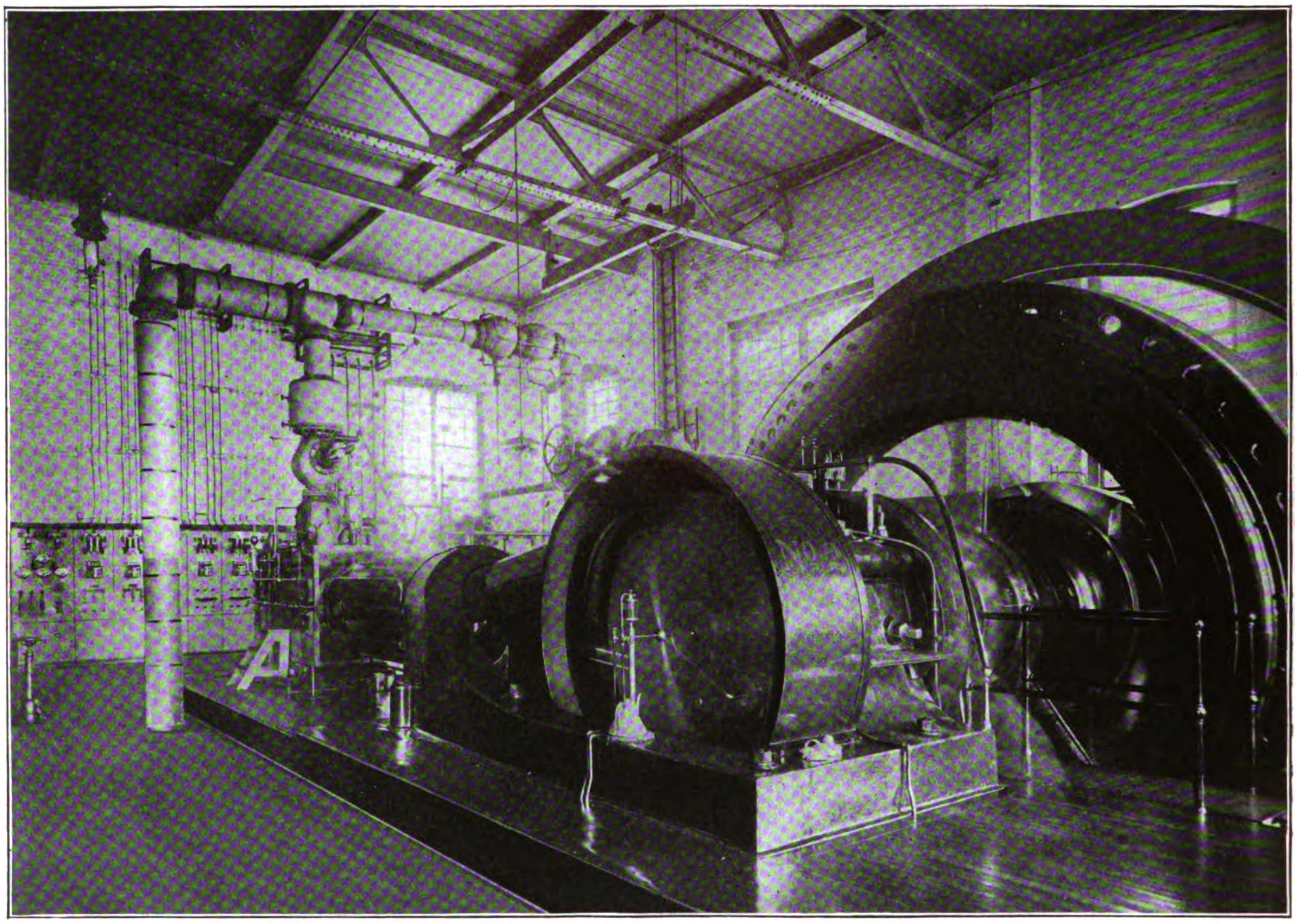


FIG. 2.—750-KW. ALTERNATOR DRIVEN BY 1000-H.P. ALLIS ENGINE IN THE TWINE MILL POWER HOUSE.

tors having eight poles and running at a synchronous speed of 600 r.p.m. The normal pressure is 600 volts, sufficiently high to avoid a large outlay for copper for transmission over distances common in such factory work, viz., 2000 and 3000 ft., and yet sufficiently low to keep down the fire risk and to avoid difficulties in the winding of the motors.

Of motors there are now 65 in service, doing their work in various locations, a great many of which are unusually severe. In an atmosphere filled with sawdust in the wood-working departments, with grit and smoke in the foundries, or with fine hemp in the twine works, the motors run without dust-tight enclosing shells, but with the usual ventilating openings. Those in the twine mill have been in service for over two years and no bearings have required renewal as yet, there having been no wear sufficient to cause rubbing of the rotating element on the stationary member even with the small clearance peculiar to the induction type of machine. On every other Sunday the dust is blown out from the interior of the motors by means of compressed air in order to prevent too great an accumulation. Excepting this slight attention and the usual oiling, the motors call for no care.

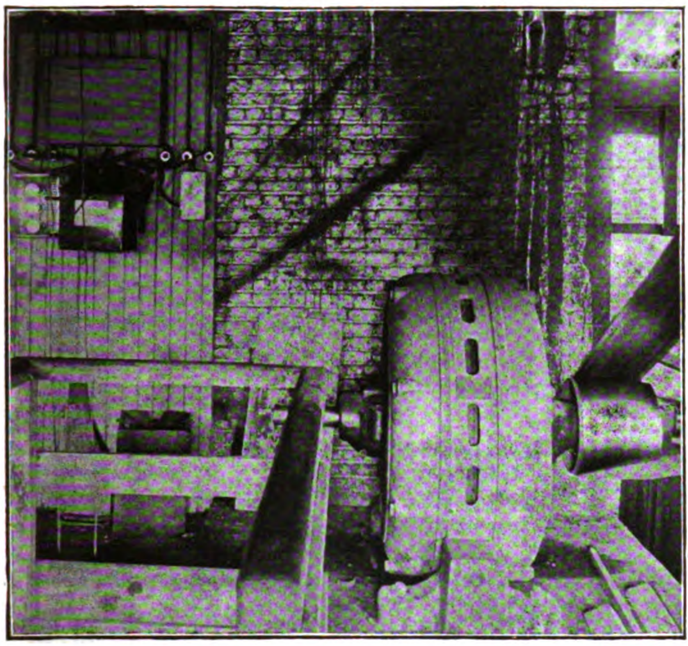


FIG. 4.—A MOTOR IN ONE OF THE IRON FOUNDRIES.

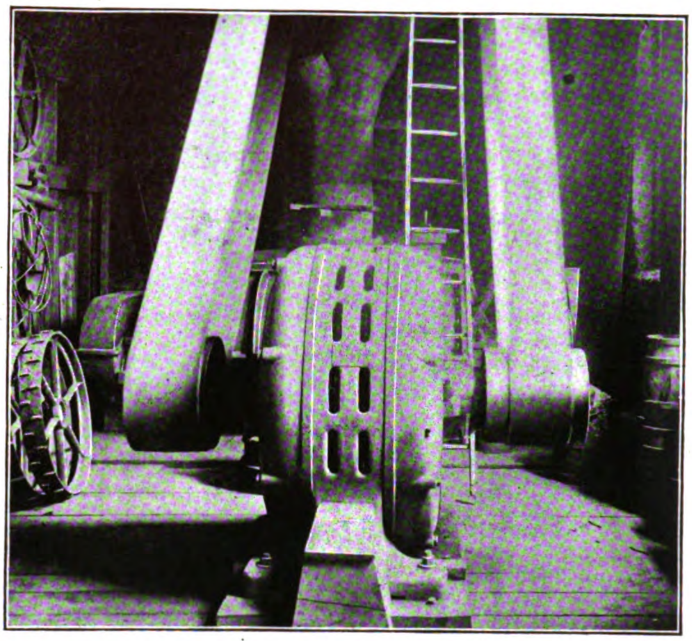


FIG. 5.—A MOTOR DRIVING FOUNDRY BLOWERS.

As shown by the accompanying views, the motors are similar to the standard G. E. type with the exceptions that each has its shaft extended in both directions, so that pulleys can be put on either or both ends of the shaft, and that there is no resistance in the rotating element for starting. In some cases the motors are mounted right side up on the floor or a platform, in other cases they are suspended from the ceiling, and in still others they are mounted on the wall. In order to make it possible to keep a good load factor on each motor, several sizes have been made with bases of the same size, so that they can be readily interchanged, using the same bolt holes. All of the motors have short-circuited secondaries of the squirrel-cage type.

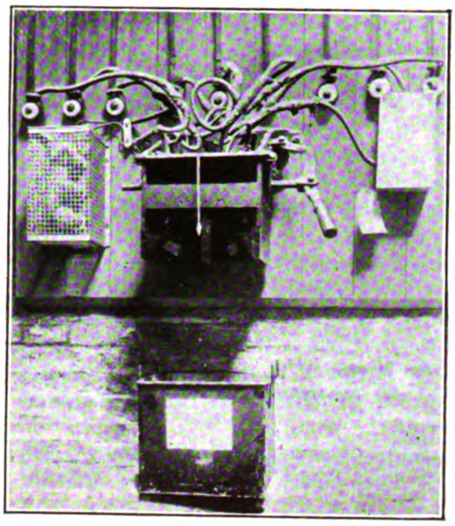


FIG. 3—A MOTOR-STARTING SWITCH.

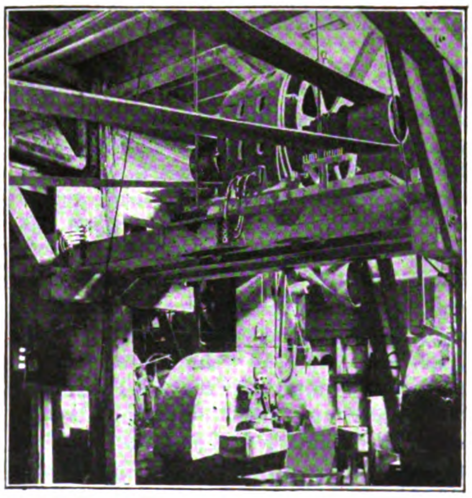


FIG. 6.—A MOTOR IN THE KNIFE WORKS.

Another special arrangement devised by the Deering engineers and worked up originally in this plant and now giving great satisfaction, is the starting apparatus. All of the larger motors are started by water rheostats designed to cut down the rush of current to the motor at standstill and low speeds, the resistance of the water being such as to allow sufficient current to pass to start the motor against the friction of the shafting and belting which is to be started up with it. The water rheostat for one motor consists of three rectangular 8 in.x10 in. glass jars similar to storage-battery jars, packed with sawdust in sheet-iron cases. Iron plates dip into the water in these jars, the resistance of the water being lowered by means of acid to a point such that the motor will start with certainty. A layer of lard oil is then poured over the surface of the water to seal it against evaporation, and in extremely dusty locations the jars are covered with lids. Many of these water rheostats have been in service since December last and no renewal of their contents has been necessary. While these water rheostats do not cut down the current taken from the line to a lower value than that required by the motor, as do compensators or auto-transformers, they improve the power factor of the starting current, and appear to be very reliable and satisfactory when in operation.

The controlling mechanism of each motor comprises also a double-throw triple-pole oil switch of the type shown in Fig. 3, which was specially developed by the electrical engineer of this plant. The switch is of simple construction, as the illustration shows, the blades extending downward into a bath of oil to prevent an arc from following on the opening of the switch. An arm outside of the oil tank indicates the position of the switch and a pin is provided to lock the switch handle in either the running or the off position. The starting position cuts in the water rheostats in series with the supply to the motor and the running position, of course, connects the motor straight to the line, cutting out the water rheostats.

Three 250-volt lamps are connected in

series with each other across one phase, thus getting 600 volts, to serve as a pilot indicator of the pressure on the system. The motor is also fused with three fuse blocks of special form designed to take strands of No. 20 copper wire, the number of these strands being proportioned to the rated power of the motor. There is also inserted in one lead to the motor, as shown in the right-hand side of Fig. 3, a removable link, by means of which an ammeter can be readily cut in at any time to determine the load on the motor.

Tests were made by the writer to determine the value of the water rheostat as a means of cutting down the starting current, and particularly as a means of reducing the fall of the line potential on starting. One test was on a motor rated at 75 horse-power belted to a line shaft about 100 ft. long, in turn belted to about 15 tumblers in the gray-iron foundry. The motor was called upon to start the line shaft and all the belts to the tumblers, no belt-shifting devices being used, the tumblers being stopped by simply throwing off idlers, allowing the belts to slip around the tumbler pulleys; all the idlers were thrown off when the test was made. Started with the water resistances in series with the motor, the maximum current at the instant of starting was 300 amperes per leg and the fall of pressure at the motor was 75 volts out of the normal 600. With this current the motor started the line shaft and belts promptly. When started without the water, the motor being thrown straight across the lines, the current rose to 600 amperes at the first rush and the pressure fell to 475 volts.

It is interesting to note in this connection that the rated full-load current of a 75-h.p. three-phase 600-volt indication motor, assuming a power factor of 90 per cent and an efficiency of 92 per cent, is 65 amperes per wire. Thus the motor showed an overload of over 300 per cent when starting with the water and of about 800 per cent when thrown straight across the line, but it must be noted that this overload is extremely brief and there is nothing in the motor, in the way of a commutator or brushes, to be injured by it. No mechanical strains proportional to the excessive current are set up, the acceleration being smooth and the motor starting without a jerk. The only harmful effect of the overload is the voltage drop, which, as given above, is not serious for motor work or even for lights run on the same circuit.

Another test was made on a motor rated at 50 horse-power, driving a large amount of shafting operating punching machines, etc. This motor took 230 amperes with 70 volts drop when started through the water and only 250 amperes with an 80-volt drop when thrown on without the water. In this case the saving by the use of water is not as great as in the first case, as, owing to the larger amount of shafting, a greater starting torque was required, so that the water had to be acidulated at a point such that its resistance would not materially cut down the current. Still another 50-h.p. motor took 210 amperes with a 50-volt drop started through the water and 260 amperes with a 75-volt drop started directly across the lines.

Starting overloads such as those noted above naturally suggest a doubt as to the ability of such a system to start a whole mill or factory without pulling the voltage down to too low a value, owing to the simultaneously applied demand of many motors. But with the motors operating certain sections or groups of machinery, these being in charge of a foreman or assistant foreman, as in the Deering Works, it would be impossible for all these motors to be started simultaneously unless purposely so arranged. The peak of the starting current lasts but a very few seconds, is practically instantaneous and then drops almost to zero, so this argument from an alternating-current standpoint is practically nil. With direct-current motors the start being made rheostatically and gradually, the current peak is not so high at the start, but it hangs on much longer than in induction motor working. The men are instructed to start their motors from five to ten minutes before the whistle blows, so that all shafting will be running when work is supposed to commence. The sudden standstill overloads are then thrown on.

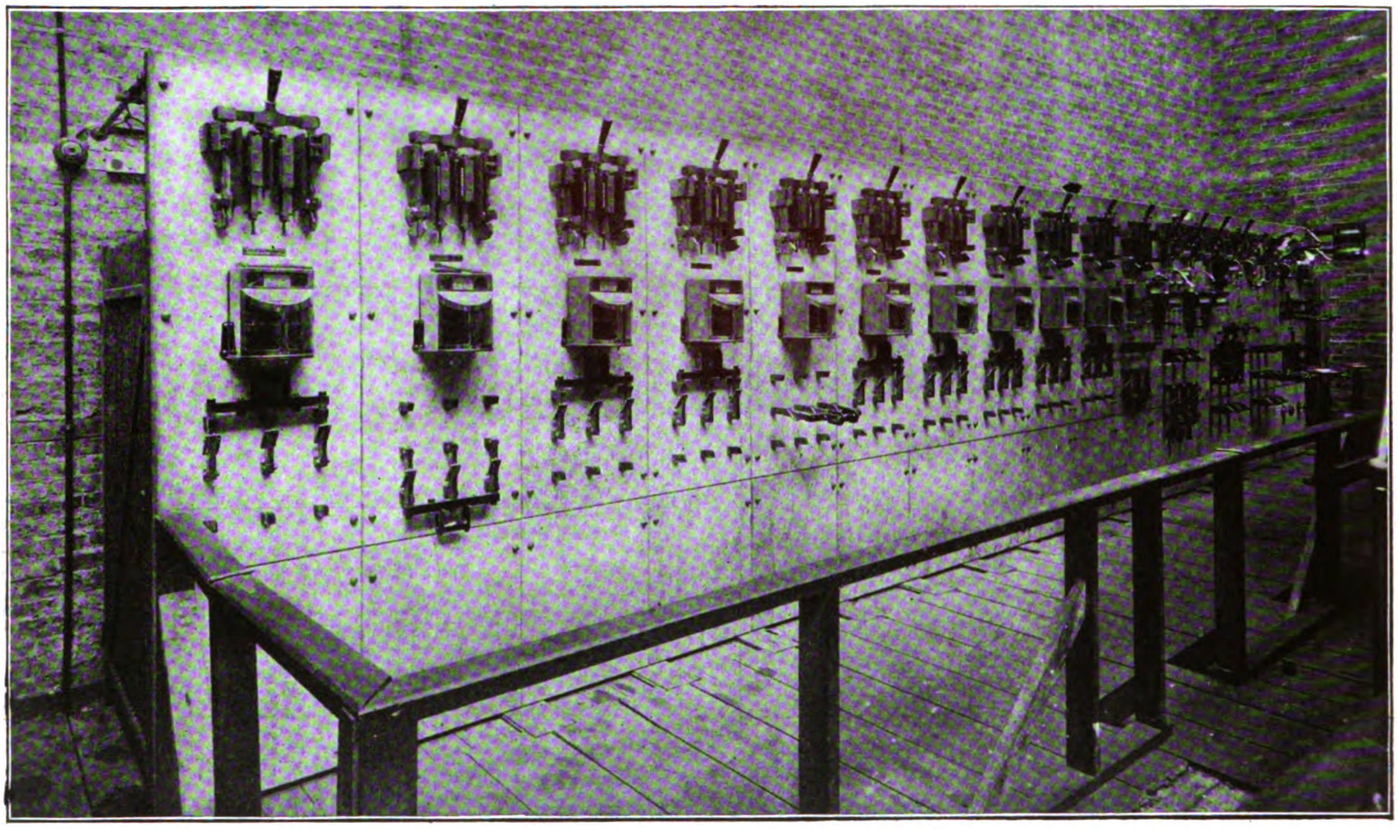


FIG 7.—VIEW OF THE LEFT-HAND END OF THE MAIN SWITCHBOARD

This is a matter that is never considered in the generating station. Foremen throw on their loads about the factory as they choose and the operator in charge of switchboard does not change his rheostats as the load is going on; in fact, pays little attention to them at all. The generator station is never affected by starting current in any way, as the independently-driven compound-wound exciter for the main generator fields maintains an almost constant voltage. The generator and lines are thus easily able to hold up a sufficiently high voltage to pull all of the apparatus up to speed quickly and without failure. An observation on the starting of this plant gave the following figures at the switchboard. About ten minutes before the whistle blew one of the main wattmeters showed that the motors were being thrown on, the needle jumping up abruptly and gradually falling back as the motors speeded up. The highest reading of the wattmeter needle noted was 900 kilowatts, the needle varying from this point down to 300 as the load was thrown on by the starting of the motors and as it fell off again when the motors approached synchronous speed and ran light under simply the friction of the shafting, no machines being started, of course, until whistle time. The load after the blowing of the whistle and after the shops had gotten into full operation was about 800 kilowatts, so that the starting load in actual kilowatts was evidently but little greater than the running load. The voltage at the switchboard fell from 600 to about 525 with the maximum starting load, the voltage at the motors, of course, falling somewhat more than this owing to the drop in the lines. The pressure at the worst-conditioned motor when starting the factory was probably 450 volts. The power factor of the whole load, when the factory is in operation, is said to be 85 per cent.

An essential consideration in starting a large number of motors in this way is the operation of the exciter by a separate prime mover. The exciter in this case is driven by its own engine, so that when a sudden starting load comes on the generator any fall of voltage is not augmented by a fall of excitation due to the effect of reduced speed on the exciter. With the separately-driven exciter the excitation of the main generator remains at full strength even if the load comes on so heavily and suddenly as to pull down the speed somewhat. In this way the generator is better able to keep up the voltage than if its field excitation falls off along with other depressing influences. The generator in operation when this observation was made was an 1100-kw. machine with a specified regulation of 7 per cent, this regulation being, of course, based on throwing off full non-inductive load. The actual variation of exciting current to retain the rated pressure of 600 volts with the lagging load thrown on by the induction motors of this plant is from 110 amperes at no load to 150 amperes at full load, the exciter e.m.f. being 125 volts.

It has been proposed to start and stop this factory by simply leaving the motors all in circuit and starting up and shutting down the main engine. In starting in this way the field of the generator would be brought up to full excitation before the engine is started, and the voltage and frequency would rise with the speed. The motors would also speed up in time with the engine and generator, always running nearly in synchronism and hence economically. They would call for practically no more current at any speed than that required to drive the load upon them at full speed. The Deering Company has experimentally demonstrated this method to be eminently practical and successful. The starting of large load in motors from the throttle of the engine is accomplished without any excessive rush of current. There is very little jerking of the meter needles forward and back. The generator starts from zero cycles and the motors do likewise; the current gradually rises to the load that may happen to be on the motors. The motors are well under speed, of course, before any sign of voltage rise appears at the signal lamps. On one occasion 1350 horse-power of induction motors located at different points of the plant were started from the throttle of an engine direct-coupled to a 750-kw. three-phase generator. The current rise for this start did not exceed 750 amperes; the impulses of current were slow and gradual. At half speed of the engine the current was about 600 amperes. The engine was brought up to speed in about one minute under full field excitation. Of course some of this motor load was thrown off after the start was made, the arrangement being for an experimental demonstration of the practicability of starting large loads in this way. This method of operation may be adopted later on when construction is finished and the motor divisions finally arranged.

For operating all of these motors the original 1000-h.p. plant in the twine mill is, of course, insufficient, and a new central power house is now under construction, part of it having been completed and put in operation. The new power house is planned for four 1100-kw. generating units, one of which is now in operation, another under erection and a third contracted for. These units will all be alike and of the type shown in the illustration of the first one on the first page of this article. The alternator is a standard General Electric revolving-field generator, weighing 60 tons, and rated to give 1060 amperes per phase at 600 volts, which, non-inductive, amounts to 1100 kilowatts total. The machine is cable wound with a continuous winding in six slots per pole. The coils, in bar form, are made up of large number of stranded wires. Each machine is mounted between the cranks of an Allis-Corliss vertical two-bearing

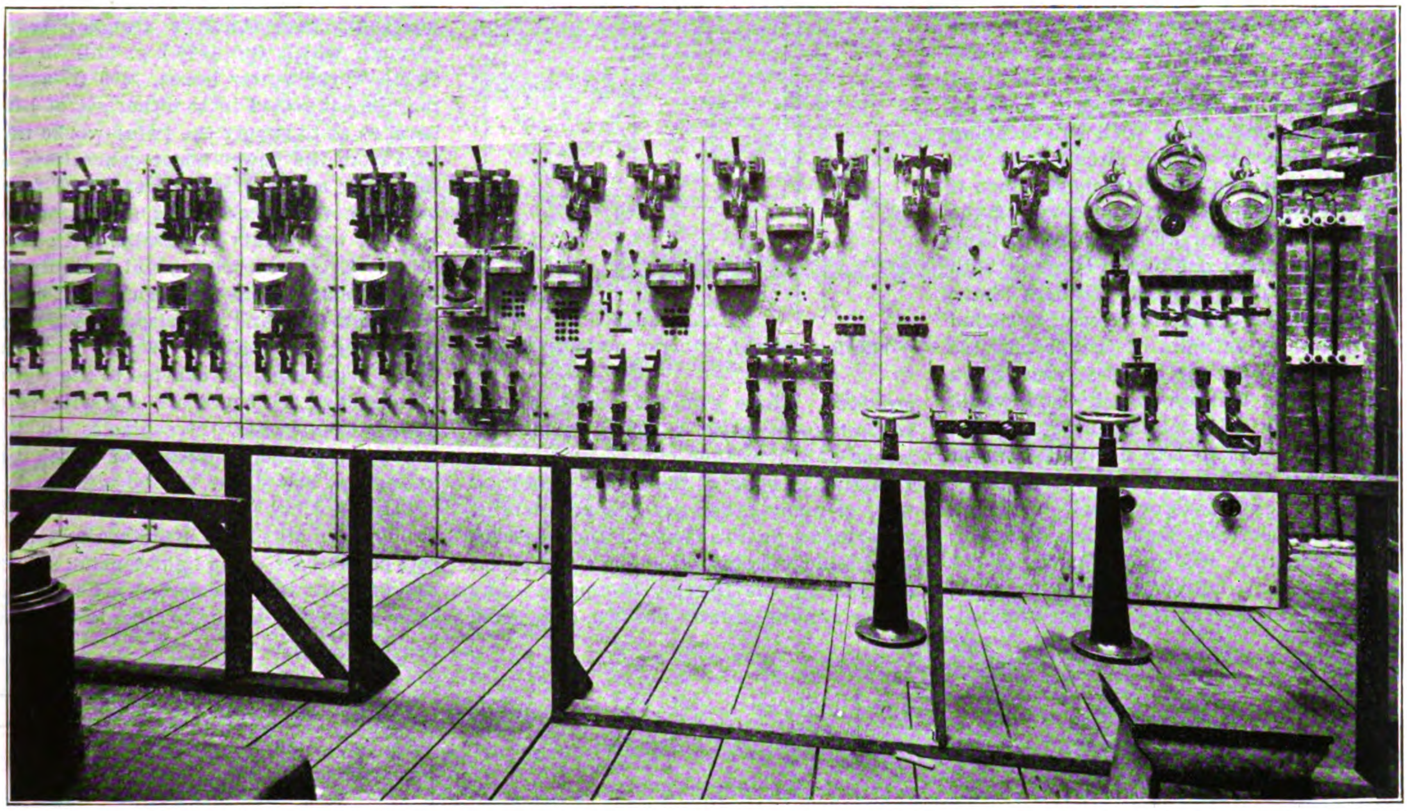


FIG. 8.—VIEW OF THE RIGHT-HAND END OF THE MAIN SWITCHBOARD.

cross-compound 28 and 60-in. x 48-in. engine, running at 90½ r.p.m., so as to generate the requisite 40 cycles with the 52-pole generator.

The switchboard of this plant is of interest in that it was specially designed by the Deering Company's electrical department to meet the peculiar needs of this work. The present main board, of blue Vermont marble, is 34 ft. long and when a contemplated extension is added will be 50 ft. long and contain 21 panels. The twine works distributing switchboard is 27 ft. long and contains 9 panels. The principle of feeder distribution has been followed out in the switchboard design and outside construction. The factory is divided up into sections, each section fed by its own set of feeders and represented by a feeder panel in the switchboard. A general idea of its arrangement can be obtained from the two views given by Figs. 7 and 8. To the left are 11 feeder panels, each equipped with a triple-pole quick-break throw-over switch, a Thomson recording watt-hour meter, and a circuit-breaker. The latter is an I. T. E. instrument, double-pole, with two tripping coils. One leg of the circuit does not pass through the circuit-breaker, since it is sufficient to open two legs to cut off the current and since an overload on any phase will affect one or the other or both tripping coils. Circuit-breakers have been found preferable to fuses of any kind in this work in spite of the permissible rush of current for a brief interval on starting the factory, which rush would appear from a direct-current standpoint to be sufficient to trip a circuit-breaker properly adjusted to protect the feeder against a continuous overload. From an alternating-current standpoint, however, with induction and synchronous motors in operation, and with the feeder lines figured on an alternating-current basis, allowing 85 per cent power factor and 2½ per cent energy loss, this consideration has not interfered practically at all and it is not likely to if any leading current or condensive effect is employed. It might interfere if the copper were figured on too close a margin.

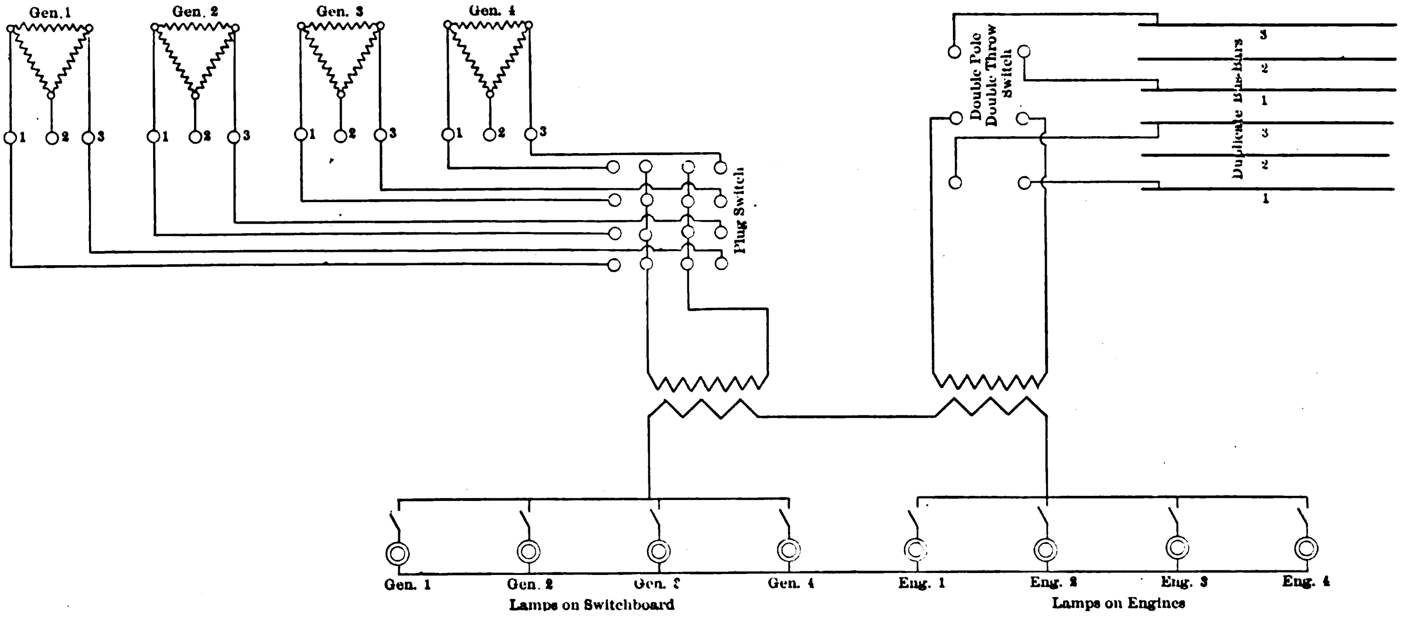


FIG.—10.—DIAGRAM OF PHASING TRANSFORMERS, LAMPS AND CONNECTIONS.

The switches are double-throw to connect the feeders to either of the duplicate sets of bus-bars with which the board is provided. These switches are of a convenient form with a spade handle by means of which they can be readily manipulated in spite of their size. They, as well as many other switchboard details, were made by the General Incandescent Arc Light Company after plans and specifications by the Deering Company. Any feeder can be readily thrown over from one set of bus-bars to the other without fear of disturbance of the operation of the motors, it being customary to hold the circuit-breaker closed when the feeder is thrown over in order to prevent it from coming out if by chance the motors are heavily loaded and slow down a trifle while the switch is open and the generator onto which they are thrown is running faster than the generator from which they were previously supplied. In this case the rush of current is sometimes sufficient to trip the feeder-breaker on well-loaded circuits.

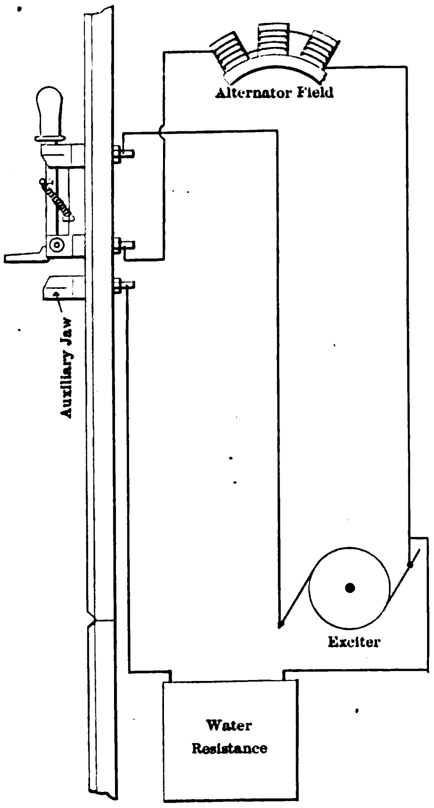


FIG. 9.—SPECIAL EXCITER SWITCH AND CONNECTIONS.

The right-hand end of the board is occupied by an exciter panel at the extreme end. On this exciter panel are field switches of the quick-break pattern, single-pole, with a projecting heel and auxiliary jaw. The object of this switch is to break the high inductive effect of the field through a water resistance. This scheme was developed at Deering and takes the place of the ordinary two-pole switches shown on the exciter panel in the main view of the switchboard, which are not used now. The improved arrangement is shown in Fig. 9. There are two generator panels and a transfer panel through which the 1000-h.p. unit in the twine works power house, 1800 ft. away, may be connected in to either set of bus-bars, so as to supply the twine-works motors from the power-house generators, or to supply some of the power-house feeders from the twine-works generators or run the two plants in parallel with each other. Each generator panel is equipped with a main switch, two horizontal edgewise ammeters and a horizontal edgewise indicating wattmeter; Wagner instruments being used. Bracketed to the right-hand end of the board are edgewise voltmeters connected to receptacles on the generator panels, by means of which the voltage on any phase can be measured.

There are but two synchronizing transformers for all of the machines and both sets of bus-bars. The light-tension side of one of these transformers can be thrown over from the upper to the lower bus-bars by means of the double-pole double-throw switch shown on the twine-works transfer panel, the fourth from the right-hand end of the board. The high-tension side of the other transformer is connect-able by means of receptacles and plugs to any machine or the transfer line. Two synchronizing lamps are used in the secondary circuit of the transformers. These lamps are so arranged that by means of small single-point switches they may be used where most convenient for the synchronizing process that may be called for. One lamp may be used on the switchboard or at the throttle of the engine, as may be demanded; its series mate would be the one on the panel of the generator to be thrown in multiple. Inasmuch as the man at the throttle practically guides the phasing, the lamp on the engine assists him and the other series lamp on the panel at the switchboard serves as a guide for the man at the switch.

The field rheostats of the generators are operated through floor stands. To the left of the twine-works transfer panel is another transfer panel connected to a 250-kw. synchronous machine in the old lighting station, this machine running at times as a generator driven from the line shaft of the lighting station, and at other times as a synchronous motor to operate the high-frequency single-phase lighting machines and arc dynamos from the central power plant. This old lighting station will eventually be abandoned, all lighting being carried direct from the central power plant. When this is done the synchronous motor will probably be used at some other point in the factory and will, with another synchronous motor of 400 horse-power, which will probably be installed later, serve to improve the power factory of the generators by over excitation of the motor fields and the introduction thereby of leading currents.

The rear of the board shows unusual care in design, as indicated by the view of the generator end in Fig. 14. A special feature designed in connection with this plant is the three-cornered clamp for fastening the generator and feeder leads to the bus-bars. This readily permits increase or decrease of copper as might be desired; the arrangement of this clamp is clearly shown in the illustration. The conducting cables in the power station are covered with a slow-burning insulation in addition to the usual protection.

The total electrical capacity of the generators and motors of this plant at present is very close to 10,000 horse-power.

The lay-out of the coal handling and steam-piping parts of the power plant is as thorough and up to date as that of the electrical. Structurally the plant is housed in the usual two parallel bays with a fire-wall division between them, a 20-ton crane being provided to serve the engine room. Nearly two-thirds of the engine-room roof and one-half the boiler-room roof consist of wired glass. The swinging windows in the side of the monitor over the engine room are arranged to be closed automatically in case of fire, being pulled open by means of a chain containing a fusible link which melts and allows the windows to close when heated. The side windows in the engine room are also pivoted above their center of gravity and held open by a similar fusible arrangement so that they also close automatically in case of fire. The roof is faced internally with unglazed tile which will not sweat.

Although the plant stands close to the north branch of the Chicago River, fuel will be obtained from railroad cars and transferred by means of conveyors into bunkers over the boiler room, the arrangement of this part of the plant being shown by the cross section, Fig. 11. The conveyor arrangement is a little unusual, two conveyors being used, one over and under each row of boiler settings each side of the fire room. From the bunkers the coal will descend to automatic stokers under Heine boilers. The plans provide space for 6½ batteries of boilers, each battery containing two boilers, each rated at 700 horse-power on a basis of 10 sq. ft. of heating surface per horse-power; this will give approximately 10,000 horse-power. A considerable saving of coal is accomplished in this plant by the use of shavings from the wood-working departments, which are handled by automatic conveyors, dumping them into bins over the boilers. A chimney is now in process of erection which will be 250 ft. high with a bore of 16 ft. 3 in.

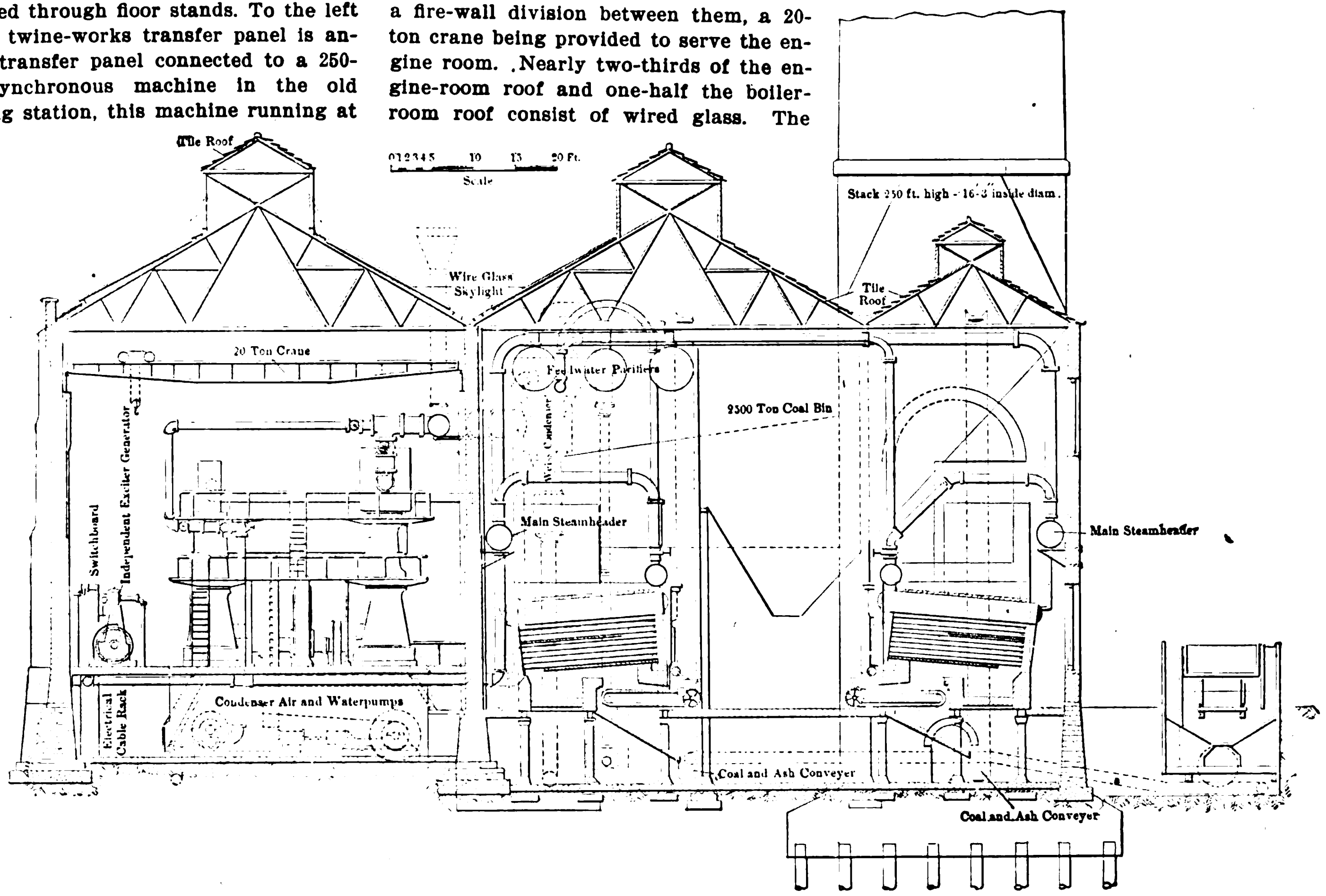


FIG. 11.—CROSS-SECTIONAL ELEVATION OF THE POWER HOUSE

The engines exhaust into a central condensing plant consisting of a Weiss counter-current condenser made by the Southwark Foundry & Machine Company. A view of this condenser is given by Fig. 13, and Fig. 12 is a typical illustration of it. The condensing vessel has a capacity to condense the steam exhausted from 5400 horse-power of engines, on a basis of 13 pounds of steam per horse-power per hour, and is designed to maintain a vacuum of 26 ins. when using cooling water at a temperature of 65° Fahr. The auxiliary machinery, consisting of air and water pumps and an engine for driving them, as at present installed has a capacity of 3600 horse-power on the basis before mentioned. Eventually, when the plant is completed, another similar condenser will be located at the other end of the boiler room, taking steam from the same vacuum exhaust header.

This condenser, which is of the jet type, forms its vacuum by the weight of the descending water. Cold water is raised to it by a Bibus rotary pump belt-driven by a horizontal Weiss combined air pump and engine located in the basement under the engine-room floor between the generator foundations. The condensing vessel is of large volume, affording ample opportunity for the steam and water to come in thorough contact, so that condensation is rapid, the water absorbing the maximum quantity of heat. The vessel, which is of steel plate construction, terminates in a barometric tube, the lower end of which is submerged in the hot well. This tube is also of large size, having considerably greater sectional area than the water inlet nozzle of the vessel, thereby making it absolutely impossible for the water to back up and flood the exhaust steam pipe and the main engines. The air pump is literally what its name implies; it handles no water whatever, the air passing through a separator on its way from the condenser to the pump, and being relieved of moisture.

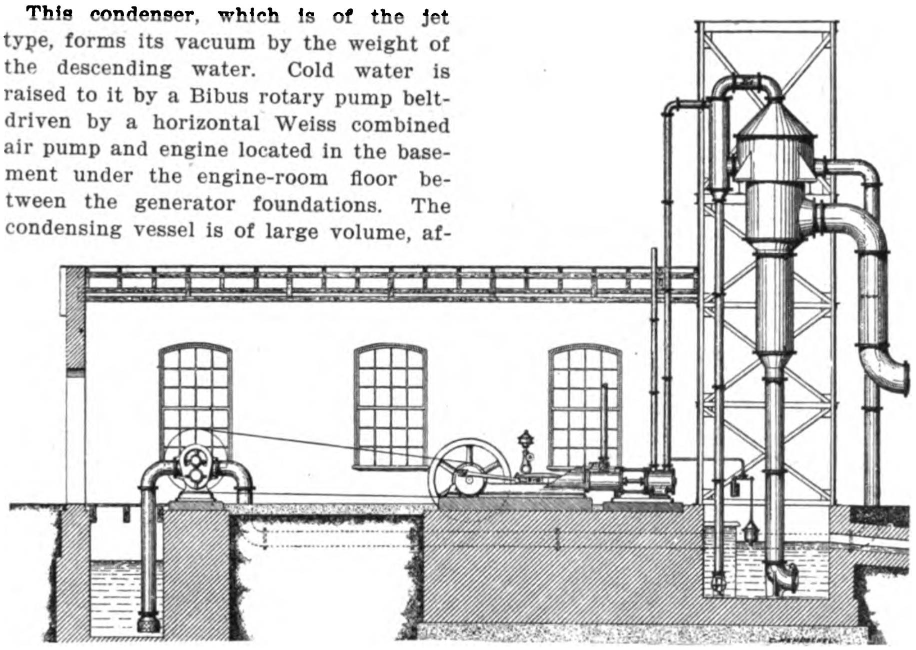


FIG. 12.—ILLUSTRATING THE ARRANGEMENT OF THE WEISS CONDENSING PLANT.

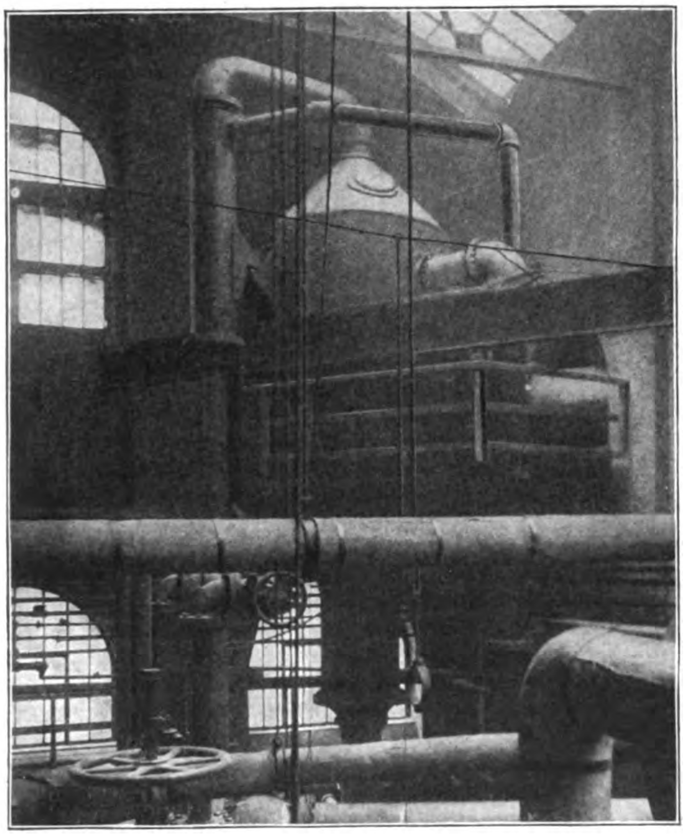


FIG. 13.—A VIEW OF THE WEISS CONDENSER.

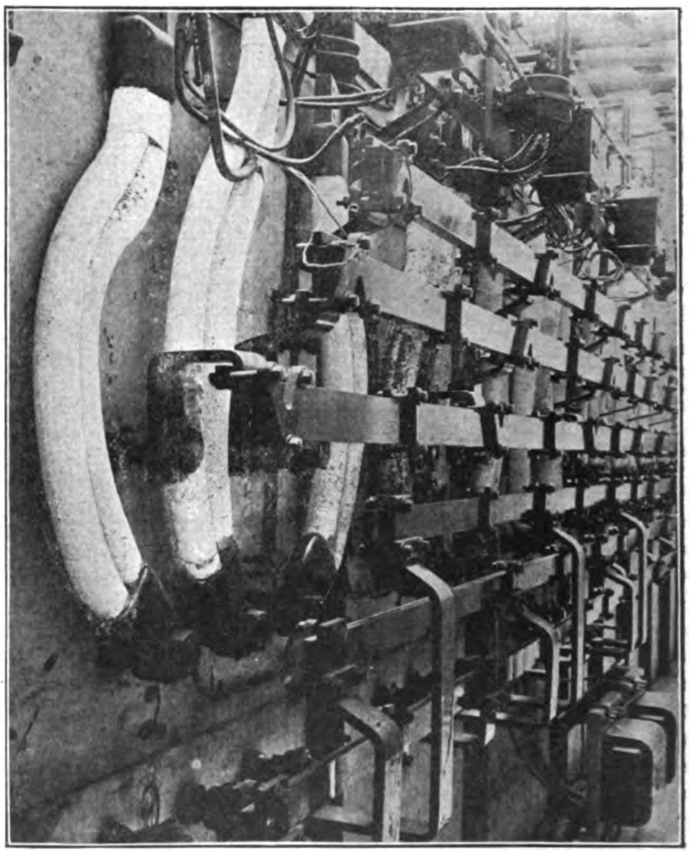


FIG. 14.—CONNECTIONS ON BACK OF SWITCHBOARD

The feed water is warmed by a 4000-h.p. Cochrane feed-water heater and purifier, using the exhaust steam of the auxiliary machines. Hoppes feed-water purifiers aggregating 2500 horse-power are also used to avoid the introduction of oil into the feed water. The latter is delivered to the boiler at a temperature of 360° Fahr.

As noted above, the lighting load of the factory, which amounts to about 8000 incandescent lamps and 130 arcs, will be changed over, perhaps before this article is published, from the old lighting station, with its high-frequency alternators and series arc dynamos, to the new 40-cycle central power station, with a transformer capacity of 540 kilowatts. The change is being made by putting in Wagner transformers designed for 40 cycles and a ratio of transformation of 600 to 110 volts, these transformers having an extra coil connected in series with the primary winding so that they may be connected up to take 1100 volts on the primary and give 110 on the secondary. These transformers are being gradually substituted for the older sizes and are worked temporarily on the high-frequency 1100-volt machines, the whole of the primary being in circuit. By their means the lighting can be quickly thrown over to the 600-volt 40-cycle bus-bars by changing one primary wire from the 1100-volt terminal to the 600-volt tap. There will be 45 transformers installed. The arc lamps, as well as the incandescents, will be operated on the 40-cycle circuits. In the twine mill very satisfactory lighting has been obtained on a four-wire three-phase secondary Y-connected, the fourth wire being a neutral, run from the common junction of the Y. This system is supplied by three transformers with a ratio of 600 to 110 volts with delta-connected primaries and Y-connected secondaries.

The Deering Harvester Company does practically all of its engineering and designing—mechanical, electrical and architectural. The engineering features of construction and design in connection with this plant were planned and executed by the company's engineers for these respective classes of work. These departments, having the valuable co-operation of the manufacturing engineers, have worked together to produce a thoroughly modern, simple and effective power plant. This great isolated power plant is under the charge of Mr. B. A. Kennedy, General Superintendent for the Deering Harvester Company, and the electrical system is under the immediate supervision of Mr. F. L. Stevenson, Electrical Engineer. To the former credit is due for the progressive spirit shown in the adoption of a new system on such a large scale, and to the latter and his assistants for the perfection of many of the necessary details of design, equipment and operation.

Arc Lamps for Street Lighting.

STREET LIGHTING BY SERIES ALTERNATING-CURRENT ARC LAMPS.

BY ARTHUR L. RICE.

The methods which might naturally be employed for this purpose are two in number; the equivalents of either the ordinary series constant-current system, or of the constant-potential system with lamps connected in series across the mains. An example of the former is the common system of street arc lighting, of the latter is the connection used in lighting from railroad circuits with five or six lamps in series. In either case, the lamps themselves would be constant-current arcs, and means must be provided for holding the current constant in each circuit of lamps.

In using the first method, the lamps may be arranged in series circuits, each circuit supplied by a transformer taking varying current at constant e.m.f. and delivering practically constant current at varying e.m.f., or by a constant-current alternator such as that made at one time by the Stanley Electric Company. In using the second method, the alternator would be run at constant voltage and sets of arc lamps in series would be connected across the terminals, the current being kept constant by an inductive regulator in each circuit. If the constant-current transformers are used, the transformers will be needed in addition to the alternator, but a single machine will answer for more lamps than could safely be supplied if the lamps were all in series between the terminals of one machine; the series-parallel system would require, in place of the transformers, a reactive regulating device in each circuit to hold the current constant as the resistance of the circuit changes. So far as the expense of the machinery is concerned, it would seem as if the cost of a transformer for each circuit would be about the same as that of the reactive regulator. The constant-current alternator would do away with both, but would be a more expensive machine than that for constant potential on account of the insulation difficulties involved and the low power factor. Moreover it would increase the types of generator at the station, which is undesirable.

In the matter of lamps there are available the enclosed arc to give 1600 c.p. taking 70 volts at the arc and 6 amperes, and burning, on the average, about 100 hours; the open arc taking 26.5 volts at the arc and 14.5 amperes, giving 1600 c.p. and burning about 13 hours, and the open arc of 2000 c.p. which takes 32 volts at the arc and 15 amperes and burns about 14 hours. A modification of the enclosed arc will take about 400 watts at the arc and is rated somewhat lower. The candle-powers given are those at which the lamps are rated, and are not comparable with the same ratings for direct-current lamps. The enclosed arc uses 420 watts at the arc, or 0.262 watt per candle-power; the difference of potential across the lamp would be at least 95 volts, hence the watts per candle in the lamp would be 0.356. For the open arc, the watts per candle will be 0.24 for the 2000-c.p. lamp and for the 1600-c.p. lamp 0.234 watt per candle at the arc; over the whole lamp the watts per candle-power will be 0.282 and 0.254 for the 2000 and 1600-c.p. lamps, respectively. Any style might be used on either system; the 1600-c.p. open arc is the most economical of energy, but the extra expense of trimming over that for the enclosed arc would more than make up for this. For the series circuit direct from the dynamo, the low-voltage lamp would have the advantage that it would enable more lamps to be installed on one machine; also, if constant-current transformers are to be used, the low-voltage lamps with several lamps on a transformer will call for fewer transformers and will, therefore, involve lower transformer losses. For the parallel-series system, the choice of lamps depends to a great extent, on the arrangement of the circuits and whether many circuits of few lamps, or few circuits of many lamps constitute the more convenient arrangement for any given case.

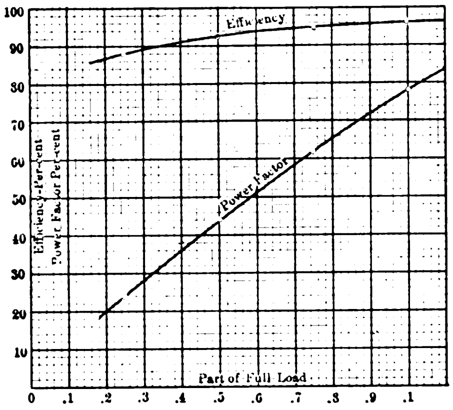


FIG. 1.—CONSTANT-CURRENT TRANSFORMER CURVES.

For series alternating-current arc lamps run either from constant-current transformers or with inductive regulators direct from the alternator, the same type of constant-potential generators would be used. They may be of any size, depending only on the flexibility and subdivision which it is desirable to give to the plant, and would have an efficiency of 90 to 95 per cent. In either case, the induction would be large and the power factor small at light loads, so that the efficiency would be much decreased unless the system were so arranged that the alternators could be kept on nearly full load while running. If the constant-current alternator be used, the induction will always be great and the power factor low, thus decreasing the capacity of the generator; the efficiency will not be over 85 per cent at any load, and will fall off very rapidly at light loads.

The line efficiency will depend, in the case of the constant-potential transmission, on the current transmitted; if the load is light, and the current therefore small, the line loss will be small, so that as lamps are cut out, the line loss will fall in proportion. In the case of series circuits from the dynamo, on the other hand, the line loss is constant, no matter what the load, so that, at light loads, the line efficiency becomes very low. This will be the case whether the series circuits are run from a constant-current dynamo, a constant-potential alternator with regulators in the circuits, or from constant-current transformers; in the latter case, however, the series transmission would probably be for only short distances, as the transformers should be located in vaults or sub-stations near to the circuits supplied.

The loss in the constant-current transformer will probably be 5 to 8 per cent at full load, and will decrease in amount but little as the load falls off, so that the percentage of loss will rise considerably. The efficiency of constant-current transformers and the power factors are given by Prof. W. L. Robb in the Trans. A. I. E. E., Vol. XVI, p. 561, and from these values the accompanying curves have been plotted. The loss in the inductive regulators will also be nearly independent of the load, but it will be less in amount than for the transformers—about 3 to 5 per cent at full load. For street lighting the question of line and transformer efficiencies at low loads is not important as such lines are generally run at nearly full load or not at all; for commercial circuits, however, it is an important point.

In the arrangement of a constant-current transformer system it is, of course, desirable to have the transformers as large as possible, but if a few lamps are needed at a considerable distance from others, a small transformer can be installed at that point to supply them, and a long detour with the series circuit from some other transformer need not be made. The subdivision in transformers can be carried as low as one lamp if it is desirable.

thus giving a great degree of flexibility. This cannot be said of the induction regulator system, as all lamps must be connected to lines run from the station, making the system difficult of arrangement where the lamps are much scattered.

The cost of the transformers will be from $12 to $18 per lamp, depending on the size of the transformers used and the voltages employed; that of the regulators for the parallel-series system will be $5 to $10 per lamp, depending on the amount of regulation for which provision is made. The other first costs will be about the same for either system, except that the line cost may be somewhat lessened, in the transformer system, by the use of high voltages, though with a slight corresponding increase in the cost of generators and transformers. A table is given below in which are compared the equipment cost and yearly operating expense for two styles of enclosed lamps on the two systems, the figures being taken, with some changes, from a paper by Mr. H. H. Wait, read before the American Institute recently.

DATA FOR TWO STYLES OF ALTERNATING-CURRENT ENCLOSED ARCS.

System.	Probable candle power.	Watts At the arc.	Watts total per lamp.	Equipment cost per lamp.	Equipment cost per c. p.	Yearly expense per lamp.	Yearly expense per c p.	Power factor.
Transformer	950	400	555	$146.50	$.154	$52.86	$.0556	0.78
Regulator	950	400	527	139.80	.147	50.75	.0535	0.89
Transformer	1,150	450	613	155.24	.1349	57.85	.0503	0.78
Regulator	1,150	450	598	153.68	.1337	54.02	.0470	0.89

The current regulation of a constant-current transformer is practically perfect, but the e.m.f. per lamp falls about 10 volts from light load to full load on account of the increase of the power factor as the coils move together and the leakage is decreased.

The induction regulator is arranged so that the sections of its coils are cut in or out of the circuit as the resistance of the load changes, thus changing the counter e.m.f. of the regulator. The change can be made either by hand or by an automatic device which cuts in coils when the current tends to increase. The energy loss is very much smaller than with a non-inductive resistance, since the drop over the inductive resistance is nearly all wattless, but the power factor of the circuit is very much lessened by the introduction of its reactance.

Not only are the transformers or regulators inductive, but the alternating-current arc lamps also introduce self-induction, due partly to the regulating mechanism of the lamp and partly to a peculiar property of the arc. The inductive effects of lamps and regulators or transformers act, however, in different ways; in transformers, as the load increases, the coils move nearer together, the magnetic leakage decreases and the inductive effect of the transformer on the dynamo circuit becomes less. In the inductive regulator the effect is of the same character because inductive resistance in the regulator will have to be thrown out of circuit as the load resistance increases, in order to keep the current constant. On the other hand, as the number of lamps in circuit increases, their induction effect is increased, thus changing oppositely to that of the transformer; hence, increases in load will change the inductive effect on the alternators only by the difference between that due to the transformers or regulators and that due to the lamps, not by their sum.

Nevertheless, the load is always more or less inductive, and reacts on the regulation and capacity of the alternator accordingly. Armature reaction in an alternator supplying a non-inductive load is comparatively small, and does not tend to cut down the e.m.f. seriously, even at large loads, if the self-induction of the armature itself is small. But an inductive load will cause the armature magnetism to oppose that of the field and thus cut down the e.m.f. generated; also the inductive load will increase the apparent resistance of the circuit so that more e.m.f. will be needed to keep up a constant current than would otherwise be required; both effects reduce the capacity of the dynamo. In the case of the constant-current transformer, a largely inductive load will tend to increase the current needed on the primary to furnish the power required by the load. The drop in the e.m.f. of the alternator, unless it be composite wound, will have to be corrected by an increase in the field excitation, and the increase in current required for a given amount of power will cut down the kilowatt capacity of the machine. These effects are common in quality, though they may be different in quantity in the two systems, and which system will suffer the less from them in any case depends on the conditions of that case.

In conclusion, both systems are practical and capable of giving good results. The cost is not materially different, but is slightly in favor of the parallel-series distribution with inductive regulators. This apparent advantage might easily be more than balanced by the greater flexibility of the transformer system and its greater convenience for a scattered arrangement of lamps. For a compactly-arranged distributing system of circuits carrying full load during a large part of the lighting hours, the regulator system would be the better; for a scattered load and with full load on the circuits for a considerable portion of the time, the transformer system is the better. Neither is well adapted to a system where a light load is on the circuits for long periods. Between the two cases mentioned fall nearly all actual cases of street lighting, and, for any given case, the character of the major part of the load must determine which system had better be used.

STREET LIGHTING.

BY H. H. WAIT.

In a paper read before the recent annual convention of the Northwestern Electrical Association, Mr. H. H. Wait continued the discussion of the cost of arc lighting and the relative economy of open and enclosed arc lamps as taken up in a communication to the American Institute of Electrical Engineers on December 27th, and an article comparing open and enclosed lamps for street lighting in the American Electrician of June, 1900. Following is an abstract of the paper:

Considering especially the intensity of illumination at the street surface obtained with different systems, it is plain that arc lamps cannot compete with incandescent lamps or Welsbach lamps placed nearer together if the minimum intensity of illumination at the street surface is the only specification to be fulfilled. The fact that alternating-current enclosed lamps give more light, relatively to their maximum, at angles near the horizontal, has led those interested in the introduction of alternating-current lamps to call particular attention to this point of minimum illumination. For example, it has been customary to hang an alternating-current lamp some distance from a direct-current open arc, and it is quite frequently found that at a point midway between the two lamps the alternating-current lamp will throw the darker shadows, and it has been claimed that the excess of light underneath the open arc is a disadvantage rather than an advantage, because it makes the less illuminated portions seem darker by comparison.

The writer wishes to again call the attention of electrical men to the danger of this method of establishing the value of street lighting on account of the competition mentioned before.

In the American Institute paper the curves of street illumination from enclosed lamps, both direct and alternating, were taken mainly from some curves submitted to the American Institute by Professor Matthews. He has since stated that these curves did not show as high efficiency as the lamps now on the market. The candle-power curves used in the accompanying diagrams were obtained by averaging a considerable number of curves published by Marks, Matthews, Thompson and Hilbish, curves made in the General Electric Company's and in the Western Electric Company's laboratories, and a number of older curves on open arcs. It is quite probable that the values obtained in this way, representing the results of the averages obtained by different experimenters using different methods, give a better idea of the relative values of the different lamps than can be obtained from tests in any single laboratory.

The candle-power curves shown in Fig. 1 are the same as those given in the June American Electrician, except that they have all been placed on one plot and the direct-current enclosed lamp with clear globe has been left out, as has also the small curve of alternating lamps without reflectors. The radial distances from the center represent the intensity of light at any given angle in candle-power. In the report submitted to the National Electric Light Association on May 23d, the luminous intensities are given in Hefner units and they consequently have to be multiplied by 0.88 to compare them with the accompanying curves. Table I gives the data relative to the curves.

Table I.

	Watts at arc.	Watts per mean spherical c.p.	Watts per mean hemispherical c.p.
I.—Direct-current open arc....	450	1.2	.8
III.—Direct-current enclosed arc; alabaster inner globe with reflector	450	..	1.2
IV.—Alternating-current arc; alabaster inner globe with reflector	450	..	1.6

It will be seen that both the direct-current and the alternating-current enclosed lamps give slightly more light at angles close to the horizontal, and also that there is a slightly greater diffusion of light directly under these lamps. At all other angles, however, the open lamp gives very much more light than either of the enclosed, and the direct-current enclosed gives quite a little more than the alternating, so that as far as the simple production of light is concerned, the old open arc is considerably superior to either of the enclosed lamps and it is only on account of the superior steadiness of the light and the lesser cost of running that makes the enclosed lamps successful competitors of the open arcs. This matter has been discussed elsewhere, and we will leave it to consider the street illumination corresponding to these curves.

The street illumination curves in the June American Electrician represent the light from a single lamp, while the curves shown in the accompanying Figs. 2 and 3 represent the illumination from a whole row of lamps located as specified. The intensity of light from the candle-power curves given in Fig. 1 is read off at the angle corresponding to the direction of the ray of light from the lamp to the point in question, and this intensity is then divided by the square of the distance to conform with the law of light radiation. The same thing is done with the lamp on the other side of the spot in question and so on to the lamps in the row on both sides, as far as they give enough light to affect the result. The summation of these intensities gives the intensity of light at the point taken without considering the direction of the light. To get the actual intensity of illumination on the street surface each value would have to be multiplied by the sine of the angle between the ray of light and the street, but as it is desired to illuminate surfaces and objects at all angles, as well as the street surface, it is probably sufficiently fair to take the bulk intensity irrespective of direction. If the sine values were used the comparison would be very much more favorable to the incandescent lamps as the light falls at more direct angles.

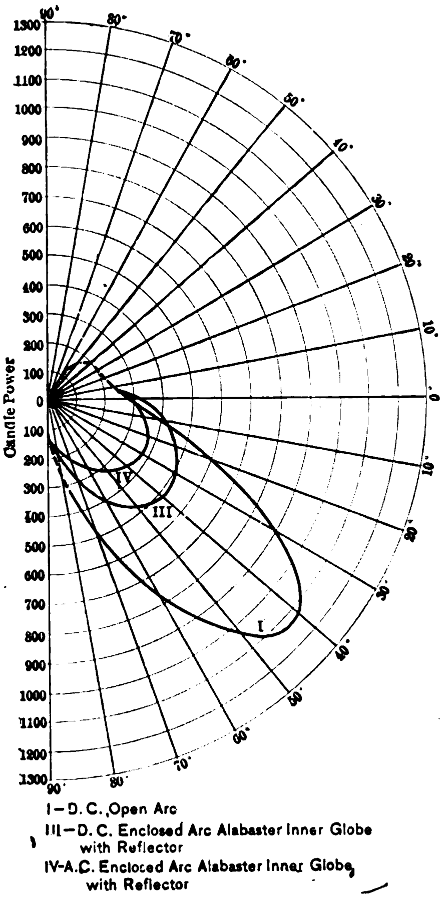


FIG. 1.—CANDLE-POWER CURVES.

The curves of Fig. 2 show the street illumination from the lamps given in Fig. 1. The arc lamps are spaced 300 feet apart and 25 feet high in this case. Superimposed on the arc lamp curves is one from bunches of incandescent lamps 150 ft. apart and 15 ft. high. Each cluster of incandescent lamps is assumed to give 100 candle-power in the lower hemisphere.

If these incandescent lamps consumed 3 watts per mean spherical candle-power (a figure which is readily obtained with modern lamps), and in addition to this we should place a reflector over each cluster which would save one-third of the light otherwise passing upward, we would then get a net figure of 2¼ watts per mean hemispherical candle-power. The enclosed direct-current and alternating lamps used in making up the arc-lamp curves were all provided with reflectors, so that the incandescent lamps are thus on approximately the same basis as the enclosed arc lamps. The open arc lamp has a very small upper hemisphere, so that a reflector would make very little difference. On the above basis the clusters of incandescent lamps would consume a total of 450 watts for every 300 ft. of space, which is the same as the power consumed by the arc lamps.

Fig. 3 shows the street illumination from the same arc lamps when spaced 600 ft. apart and 25 ft. high. Curve V superimposed on these shows the light from clusters of incandescent lamps located 100 ft. apart and 15 ft. high. This curve, V, is made up on the assumption that each bunch of lamps gives 50 candle-power in the lower atmosphere. Allowing 450 watts for each 600 ft. for either the arc lamps or the incandescent lamps would mean that we would have to get a net efficiency of 1½ watts per mean hemispherical candle-power in order to come as high as 50 candle-power per cluster. This would probably represent the maximum condition that could be reached with the present form of incandescent lamps for several years to come. This

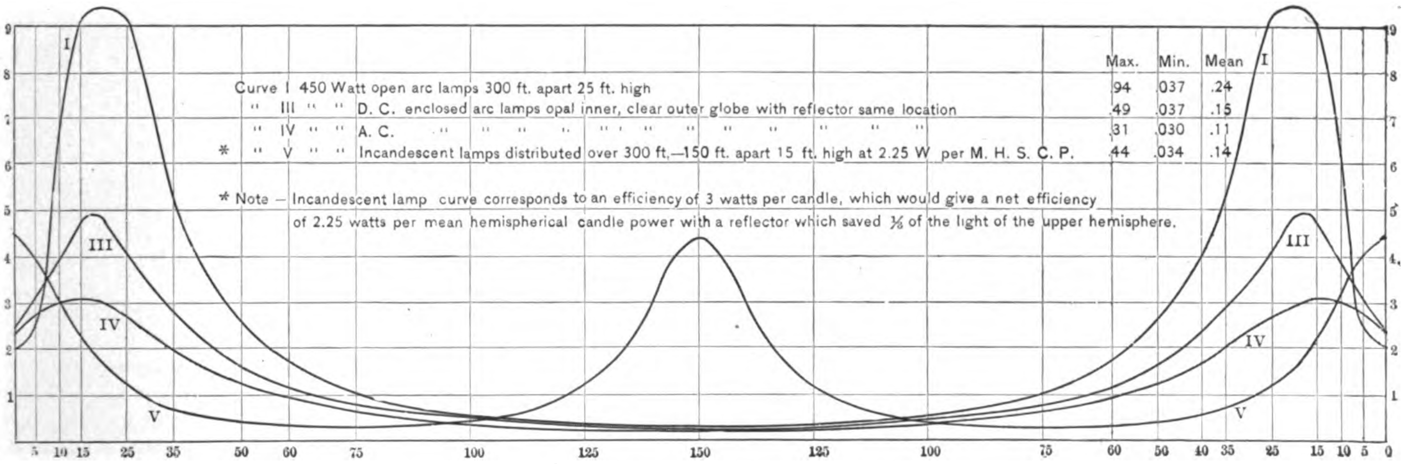


FIG. 2.—STREET ILLUMINATION CURVES.

efficiency would correspond with an efficiency in the lamp itself of 2.7 watts per mean spherical candle-power and 80 per cent efficiency in the reflector. This latter would seem to be about as high as could be obtained with a reflector which would withstand the weather.

Curve V in Fig. 3 is drawn at this efficiency to avoid confusion. In the tabular note which gives the maximum, minimum and mean values of the curves in Figs. 2 and 3, the values have been added which have been derived from curves of incandescent lamps consuming 2¼ watts per mean hemispherical candle-power as in Fig. 2, and also at an efficiency of 3 watts per mean hemispherical candle-power which could be readily obtained from incandescent lamps without the use of reflectors.

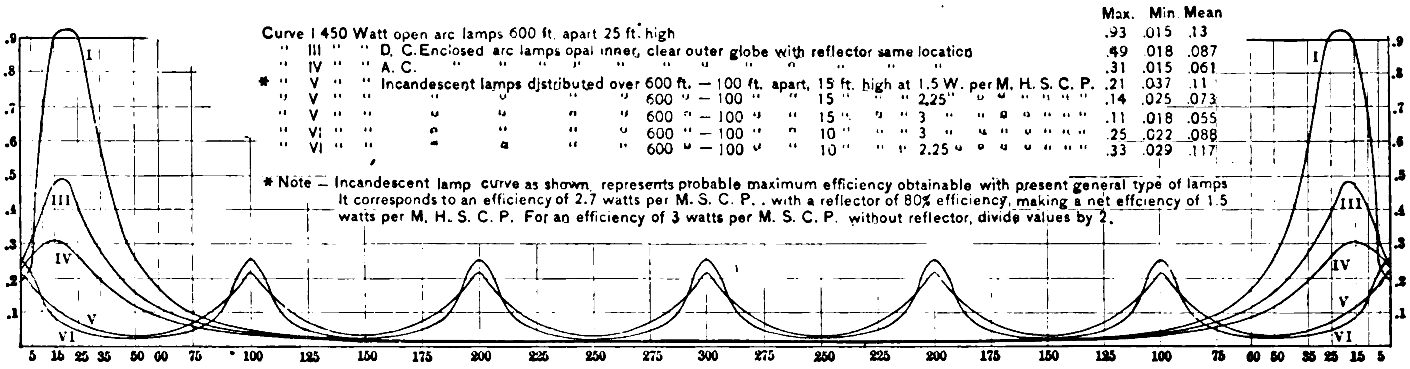


FIG. 3.—STREET ILLUMINATION CURVES.

A consideration of these curves and tables shows that at the higher values of street illumination, such as are obtained with the arc lamps located 300 ft. apart, the minimum illumination is about the same for all four methods and that there is no very great difference in the mean illumination except that the mean, as well as the maximum, for the open arc is considerably higher, the light from the alternating lamp being somewhat lower than the others for maximum, mean, and even the minimum.

At the low values of illumination, as with the arc lamps 600 ft. apart, one finds that the incandescent lamps appear more favorable, considering the minimum values. For example, at the net efficiency of 2¼ watts obtained with the reflector, which is a figure consistent with good practice, we get a minimum value of nearly double that obtained from the open arc and the alternating arc, and considerably larger than the direct-current enclosed arc. We find, however, that the maximum value from the incandescent lamps is way below the others and the mean value is lower than all the others except the alternating. This leads to the conclusion alluded to in the beginning, namely, that if we are going to have low minimum values as the only requirement specified, arc lamps cannot compete with incandescent lamps or Welsbachs. It is only by considering the mean and maximum values that arc lamps can continue to hold the field.

A consideration of the conditions leads the writer to suggest that a modern specification should comprise the following elements:

1. That the minimum illumination should not fall below a specified figure.

2. That the mean illumination should not fall below a specified figure.

3. That the fluctuation of the lamps from time to time should not cause a variation of more than 50 per cent from the above specified average figures. This clause would prevent the use of any but the best open-arc lamps, and they would have to be run in the best possible shape even then. A variation of 50 per cent in the light from an arc lamp is not very noticeable in street lighting, and if the intensity did not change more than this, there would seem to be no objection to the use of open arcs.

4. That the arc lamps should not be hung lower than a specified minimum of, say, 18 ft., and that incandescents should not be hung lower than, say, 10 ft.

It would be desirable if some specification could be adopted which would limit the amount of color allowed in the light so as to avoid the unpleasant hues of the Welsbach lights or the extreme purple of very long enclosed arcs, but there seems no reasonable commercial method of determining this except to leave it as a matter of personal opinion.

The foregoing specifications seem decidedly impracticable to apply to cases where only a small amount of lighting is to be done, but the points involved are all likely to come up and be made the subject of lawsuits in places where there is strong competition. The various electric associations should, therefore, endeavor to get the matter standardized so that the relative value of the different lamps for different purposes can be specified on a basis of watts at the arc, combined with certain restrictions in regard to carbons, globes and reflectors.

Engines and Generators at the Paris Exposition

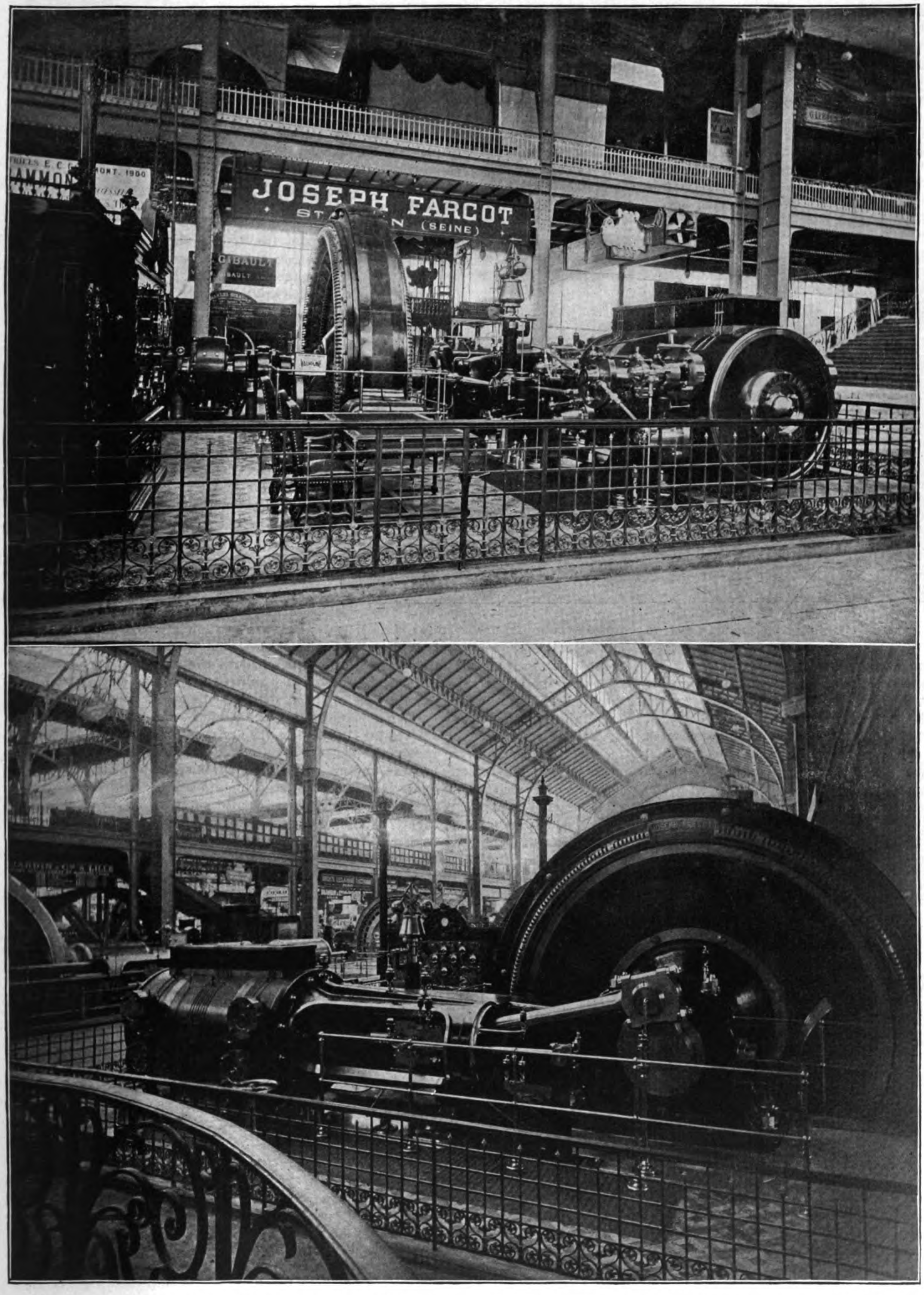
Prominent among the exhibits in the Belgian section of the Machinery Department of the Paris Exposition is a 650-h.p. gas engine designed for operation with high furnace gas, and built by the Société Cockerill, of Seraing, Belgium. This huge machine has a single cylinder 4 ft. 3 ins. in diameter and a stroke of 4 ft. 7 ins., a rather unusual ratio in gas engine construction. The normal speed is 80 r.p.m. The connecting rod is 14 ft. 5 ins. long; the crank shaft is 18 ins. in diameter, and the flywheel measures 16 ft. 5 ins. in diameter and weighs 33 tons. The total weight of the engine including the flywheel is 127 tons. The cylinder is water-jacketed, of course, and in addition to this the piston head is provided with a jacket through which cooling water circulates. The valves are of the usual lift type and actuated by cams on a secondary shaft in the ordinary manner, the latter being driven from the main shaft through spiral gears.

The mate to this engine was recently subjected to a series of tests, the results of which are given in the accompanying table. The furnace gas used had a calorific value of 102 B.T.U. per cu. ft., so that the gas consumption of 91.11 cu. ft. per indicated horse-power-hour corresponds approximately to 14½ cu. ft. of standard illuminating gas. The gas was taken from blast furnaces through a cooler, but was not subjected to any purifying process.

Admissions per minute	42
Revolutions per minute	94.2
Indicated horse-power	779
Brake horse-power	565.3
Mechanical efficiency	72.56%
Cubic feet gas per i.h.p.-hour	91.11
B. T. U. per cubic feet gas	102.4
Thermal efficiency	27.17%
B. T. U. lost in cooling water	55.13%
B. T. U. lost in exhaust	17.7%
Lbs. cooling water per i.h.p.-hour	113
Temperature of gas, Fahr., entering	48.2
Temperature of gas, Fahr., exhaust	947.3

The engine is started up by means of a winch geared temporarily to the flywheel; the engine being turned over until a charge has been drawn in and compressed. The electric ignition mechanism is so arranged that it cannot operate so long as the starting winch remains in gear. Fig. 1 illustrates this remarkable machine, which was designed by M. Edouard Delmare-Deboutteville.

Among the steam engines which attract a great deal of attention is a single-cylinder Farcot engine of about 1000 h.p., which was briefly referred to in a pre-


JOSEPH FARCOT
(SEINE)
GIBAULT

FIGS. 1 AND 2.—TWO VIEWS OF THE SINGLE-CYLINDER 1000-H.P. FARCOT ENGINE AND ALTERNATOR AT THE PARIS EXPOSITION.

vious article. Two excellent views of this engine are given by Figs. 2 and 3. The cylinder is 39.37 ins. in diameter and the stroke is 4 ft. 5 ins. The engine was designed to run at 78½ r.p.m. with a boiler pressure of 100 lbs., but the actual pressure which is available is about 86 lbs. and the actual speed of the engine is 76 r.p.m. At a pressure of 100 lbs. and a speed of 78½ r.p.m. the engine is capable of developing 900 indicated horse-power at 1/10 cut-off, 1300 indicated horse-power at 2/10 cut-off, and 1600 indicated horse-power at 3/10 cut-off. In actual operation at the Exposition the following results are stated to have been obtained: At 1/10 cut-off, 700 brake horse-power with a steam consumption of 13½ lbs.; at 2/10 cut-off, 1020 brake horse-power with a steam consumption of 14.4 lbs.; at 3/10 cut-off, 1230 brake horse-power with a consumption of 16.4 lbs. of steam. The condenser vacuum was between 27 and 28½ ins. of mercury.

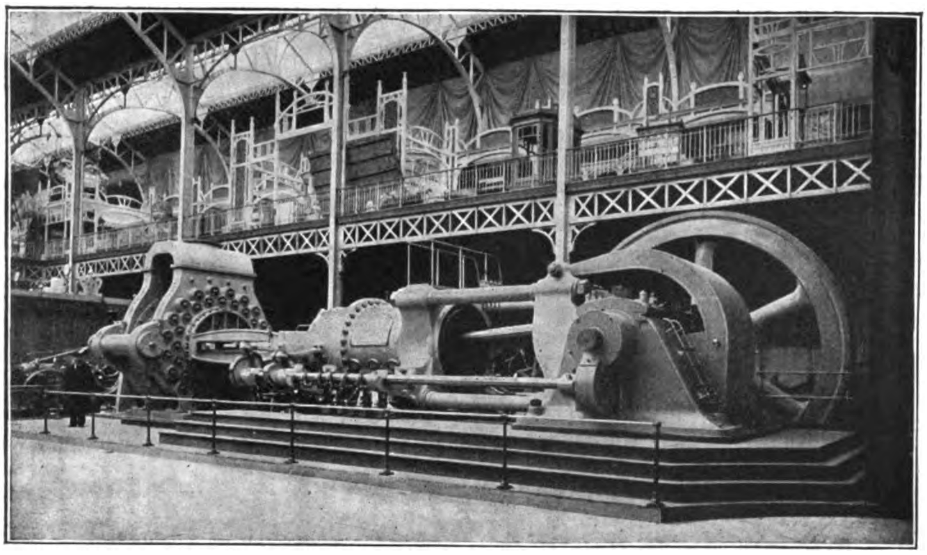


FIG. 3.—COCKERILL 650-H.P. GAS ENGINE; TO USE UNPURIFIED BLAST-FURNACE GAS.

The governor is provided with means for varying the speed of the engine while it is running, in order to facilitate synchronizing the alternator which the engine drives with other alternators in service, and also for the purpose of regulating the proportion of the load which the alternator takes after it has been thrown in. Fig. 4 is a section of the cylinder showing the arrangement of valves and steam jackets. It is evident that the live steam from the boiler first flows through the barrel jacket and thence to the head jackets in which the valves and their pockets are located. This arrangement of the valves is somewhat similar to the arrangement which has been used considerably in the United States for the purpose of reducing the cylinder clearance. In the Farcot engine the cylinder proper consists merely of a bushing inserted in the steam jacket. The front cylinder head is bolted to the frame of the engine and the barrel part rests upon a sliding stool which is provided in order to avoid trouble due to expansion and contraction of the cylinder structure. The valve mechanism is a modified Corliss gear of the crab releasing type.

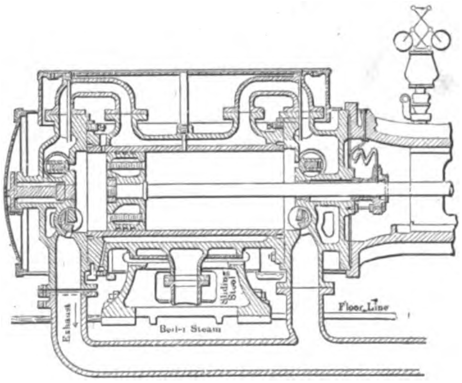
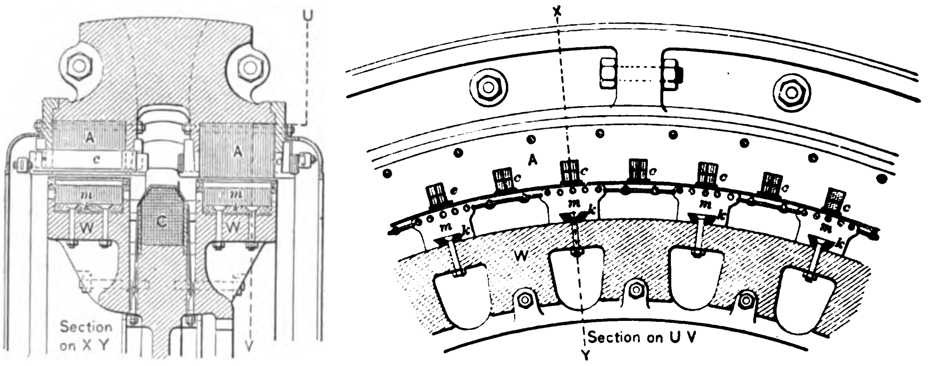


FIG. 4.—SECTION OF FARCOT CYLINDER.

The Farcot alternator is a 750-kw. inductor machine with a revolving field magnet mounted directly on the engine shaft, which also carries the armature of the exciter dynamo. The field magnet is divided into two rings, each consisting of 32 poles of laminated iron, m, bolted to the fly wheel rim, W, as shown in Figs. 5 and 6; each crown of magnet poles carries a Hutin & Leblanc "amortisseur," consisting of a copper squirrel cage, as plainly shown in the engravings; the object of this device is to prevent hunting. The laminations are held by dove-tailed iron plates, into which the retaining bolts tap. The field winding is a single coil, C, Fig. 4, concentric to the shaft, and mounted between the two crowns of magnet poles, as shown. The stationary member or armature, A, of the machine is divided into two rings corresponding with the two crowns of magnets, each ring having its own winding, c. The coils of the two rings are staggered so as to give the two phases required. The minimum diameter of the air gap is 18 ft., so that at the normal speed of 78½ r.p.m. the velocity of the pole-pieces is about 4440 ft. a minute. The shaft of the engine and generator is 17¾ ins. in diameter in the bearing next to the crank and 15¾ ins. in the bearing next to the exciter; the diameter within the fly-wheel spider is 25⅝ ins. The alternator gives 2200 volts and has a capacity of 200 amperes per phase. With a power factor of 0.85 the drop in voltage is about 10 per cent. The normal frequency is 42 cycles per second, but as the engine is not running up to normal speed its actual frequency while in use at the Exposition is 40½ cycles. The resistance of the field winding is 3⅓ ohms and the exciting current at full load is 50 amperes. The weight of the revolving member without the shaft is 110,230 lbs., and the weight of the stationary member is 132,280 lbs.



FIGS 5 AND 6.—DETAILS OF FARCOT ALTERNATOR.

Fig. 7, 8, 9 and 10 show the constructional details of the 2500-h.p. triple-expansion Borsig engine and 2000-kw. three-phase Siemens & Halske alternator, an exterior view of which was given in a previous article. As shown by Fig. 7, there are two low-pressure cylinders, one below the high-pressure cylinder and the other below the intermediate cylinder. The stroke of the engine is 47¼ ins. and the cylinder diameters are respectively 29.9 ins., 46.4 ins., and 52.7 ins. The engine was designed for a speed of 90 r.p.m., but its actual speed at the Exposition is 83⅓ r.p.m.; this speed being necessary in order to obtain a frequency of 50 cycles from the alternator. Also the engine was designed for a boiler pressure of 210 lbs. per square inch, but is working now at only 140 lbs. With the normal pressure of 210 lbs. and speed of 90 r.p.m., running condensing, the engine will develop 2500 brake horse-power with 20 expansions. The air pump is driven from a crank disc at the left-hand end of the main shaft, Fig. 7, and placed below the floor level.

The baseplate is built in two parts, each half carrying two of the crank bearings, while the central part is hollowed out in the form of a trough to collect the droppings of oil, which are forced up into a purifier by means of two small rotary pumps driven by spiral steel wire ropes from the crankshaft. Between the baseplate and the large dynamo bearings is mounted a 41½-ton fly-wheel, fitted with a toothed ring, to which is geared an electric motor, for starting the engine. The baseplate also carries two strong cast-iron pillars bolted thereto on both sides and supporting the guides. The two low-pressure cylinders are firmly bolted together and mounted on the two pillars. Above these cylinders are placed two cast-iron stools, well stayed by intermediate wrought-iron pillars, and upon these supports are set the high-pressure and intermediate cylinders.

All the cylinders (which are of cast steel) are provided with steam jackets, each heated with the steam of its own cylinder. The high-pressure cylinder piston is fitted with Ramsbottom cast-iron rings, and the three others with Buckley rings of the newest pattern. The stools placed between the upper and lower cylinders are so arranged that the upper covers and pistons of the low-pressure cylinders can be dismounted after the intermediate stays have been removed. After disconnecting the crossheads the piston rods can be lowered into suitable pits sunk in the foundation, and usually kept covered by caps on the baseplate, from whence they can be drawn up on one side of the pillar heads and removed.

The supply of steam to all the cylinders is regulated by double-beat valves fitted with Collmann's patent dashpots. They are mounted in lateral extensions of the cylinders, situated in the rear in the case of the high-pressure and intermediate cylinders, and at the sides of the low-pressure cylinders. The valve motion is driven from a shaft carried on six bracket bearings behind the low-pressure cylinders, all of the eccentric being mounted on this shaft. Motion is transmitted from the crankshaft by means of bevel-wheel gearing through a sloping intermediate shaft passing upward through the pillars and carrying spring-loaded pendulum governors.

The admission and exhaust valves of all four cylinders are worked by slip gear, the high-pressure admission valve being directly controlled by the governor, while the other valves are actuated by means of fixed detents, which, however, can be adjusted by hand. The oil dashpots peculiar to the new Collmann valve motion can be easily adjusted so that the closing of the valves becomes almost noiseless. In the case of the high-pressure and intermediate cylinders the admission valve and its corresponding exhaust valve are worked in conjunction from the same eccentric, while each of the low-pressure cylinder valves is actuated separately by

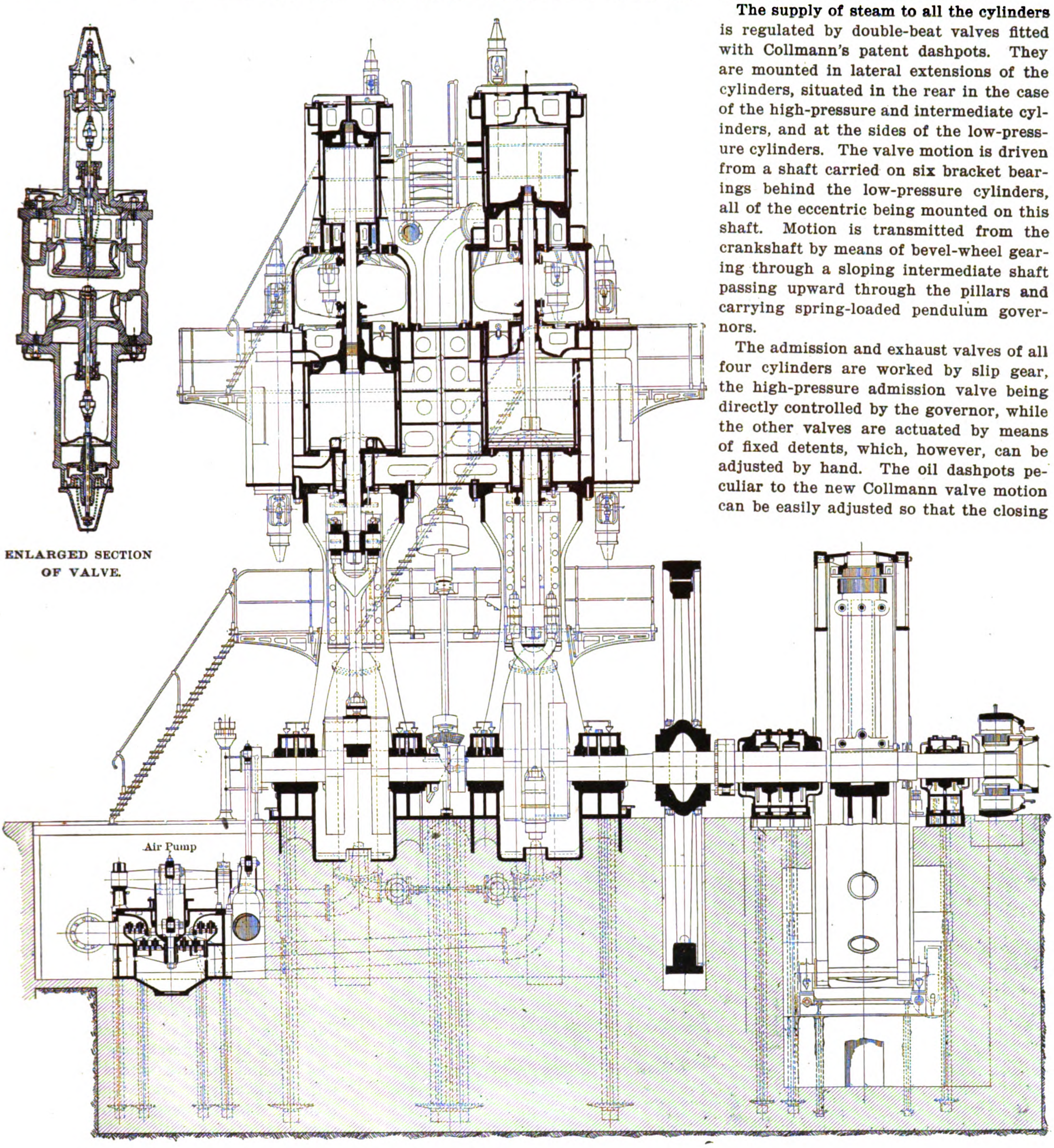


FIG. 7.—SECTIONAL ELEVATION OF THE BORSIG 2500-H.P. TRIPLE-EXPANSION ENGINE AT THE PARIS EXPOSITION.

its own eccentric. The speed of the engine can be altered while running by means of a hand-wheel acting on a spring in the dashpot box of the governor.

The inertia of the moving rods is compensated by counterpoises bolted to the cranks. The connecting rods and crossheads are of the newest pattern marine-engine type, and each of the two piston rods is made in one piece.

Oil is forced under pressure into all the stuffing boxes. For the supply of oil to the rods and bearings an oil distributor is mounted on the upper platform, the oil being delivered into this vessel by gravitation from a tank into which it is raised by a force pump in the basement. The air pumps are provided with piston and head valves only, there being no suction valves. The pistons are driven by connecting rods leading from the two ends of the air-pump lever, the shaft of which is mounted in bearings resting on the top of the air pumps. At the end nearest the engine this lever is driven from the above-mentioned disc on the crankshaft by means of a lever and intermediate rod.

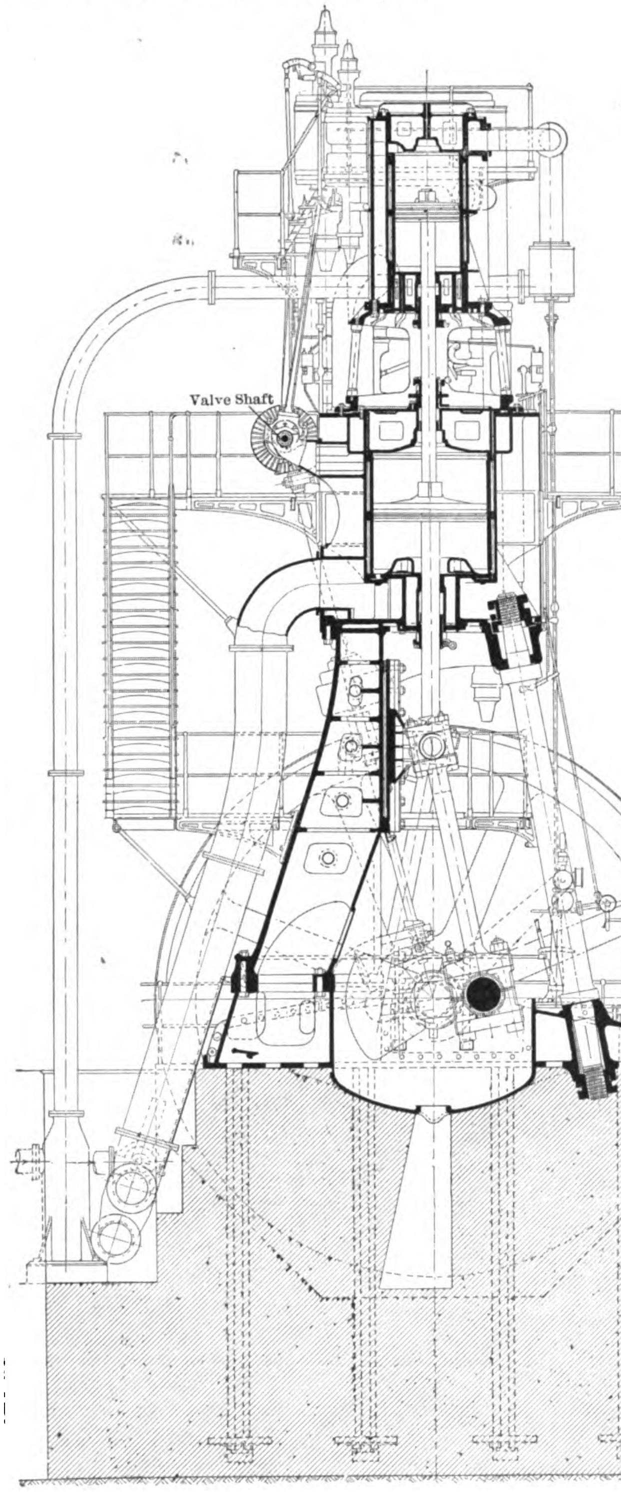
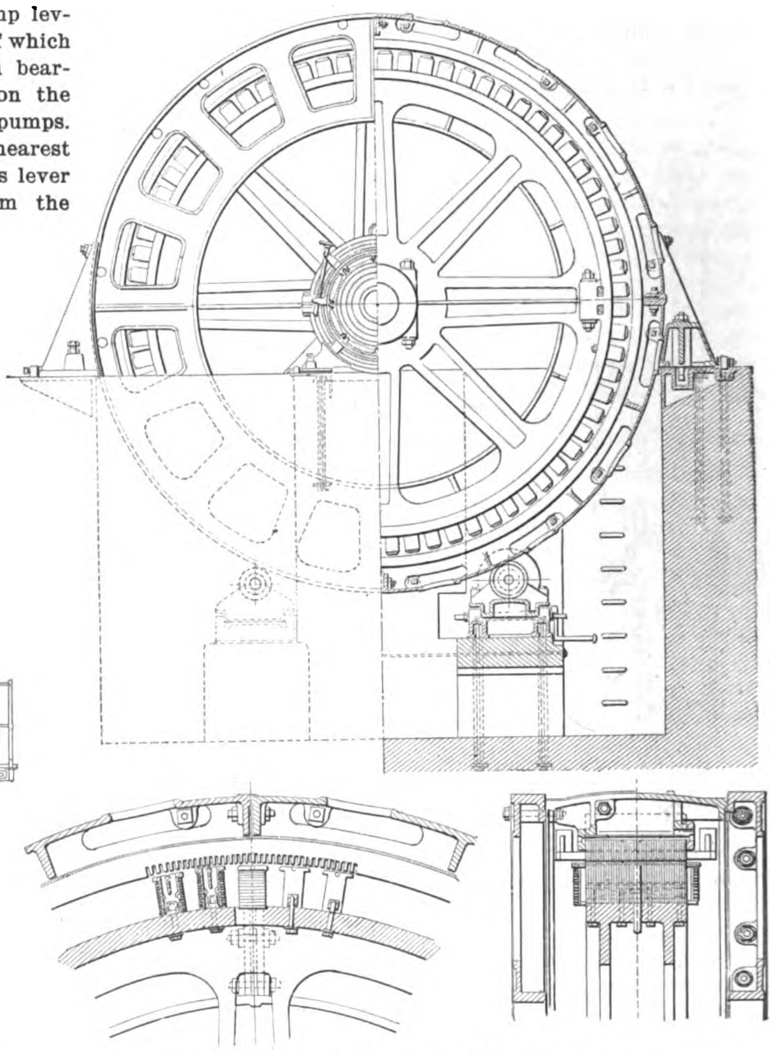


FIG. 8.—TRANSVERSE SECTIONAL ELEVATION OF BORSIG ENGINE.



FIGS. 9 AND 10.—SIEMENS & HALSKE ALTERNATOR.

The steampipe is conducted from the pipe-way at the rear of the engine to the main throttle valve situated between the high-pressure and intermediate cylinders, a short pipe leading from the valve to the front side of the high-pressure cylinder. The steam from this latter is led through a vertical copper pipe into the intermediate cylinder, and thence again through another vertical copper pipe into a cast-iron chest, from which it enters the two low-pressure cylinders. The exhaust pipes lead downward from each of the latter alongside the pillars to the two air pumps, the water-spray cocks being fixed at the lower extremity of these pipes below the floor.

At a speed of 83½ revolutions the alternator is calculated to develop 2000 kilowatts and to furnish current at 2000 to 2200 volts at 50 alternations per second. The machine is fitted with a 64-pole rotating field magnet and a stationary armature. The field-magnet structure consists of a divided cast-iron rim connected with the hub by cast spokes and keyed direct on to the extension of the engine shaft. The magnet poles are made of sheet iron, the sheets being fastened together by three bolts and a steel bar of square section, this bar being tapped for the bolts which secure the poles to the cast-iron rim. The tangential force is taken up by a sort of inverted cradle mounted on the poles and engaging in a corresponding groove in the rim. The winding on the field magnets is of flat copper wound edgewise, and at each of the end faces the copper is carried over hollow bronze castings, allowing a free radial circulation of air.

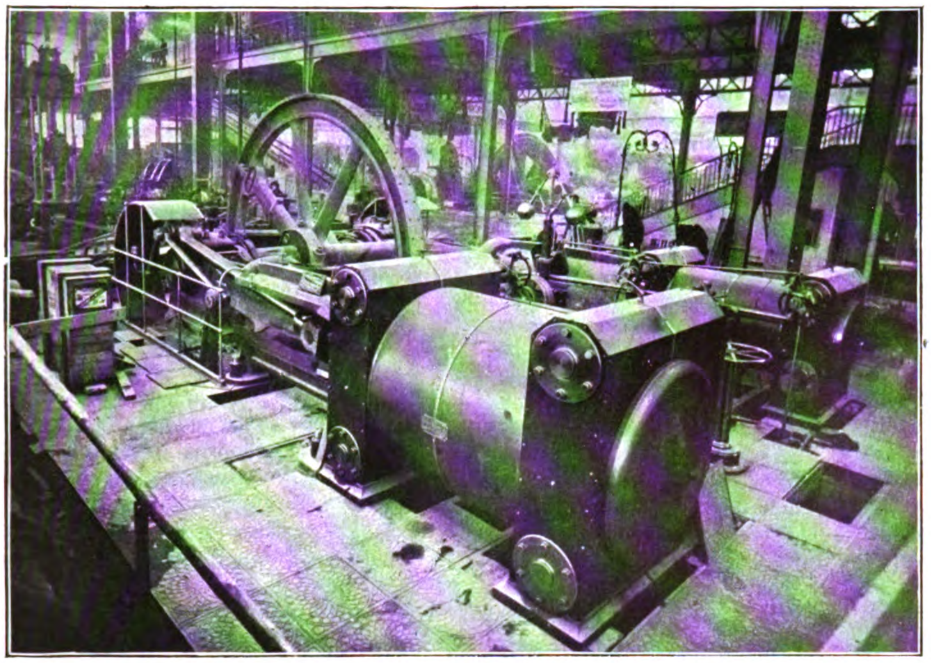


FIG. 11.—BOLLINCKX 1100-H.P CROSS-COMPOUND ENGINE.

The outer or stationary part of the machine has two supporting rims, each consisting of an outer and inner ring, made in four parts bolted together and connected by strong radial spokes. To these rims the armature is attached, this also being made in four parts, so that armature and rims constitute one solid whole. The armature laminations are 1/50 in. thick, held together and supported by suitable castings. On the outside the rims are turned smooth and are carried on two pairs of rollers, which can be adjusted vertically so as to raise or lower the central point of the outer case at will, or to adjust the same laterally by raising one pair of rollers and lowering the other. By this means the two parts of the machine can be mutually centered at any time; the supporting rims rest continually on the rollers. To prevent the outer part moving while the machine is at work, and also to take up any strains in the direction of the engine shaft, lateral supports are provided to which the rims can be bolted when set in the right position. On releasing the retaining screws the entire outer part can be turned on the rollers. The armature is wound with copper bars laid in open grooves and insulated with mica packing.

The exciter is coupled direct to the main dynamo. It is a series-wound machine capable of developing 45 kilowatts at 210 volts. This exciter is of the external-pole type, with eight poles and a cast-iron field-magnet. The armature is coil wound, and the normal output of the dynamo if driven at a speed of 340 r.p.m. is 200 kilowatts.

Among other interesting engines in the Belgian section is a Bollinckx 1100-h.p. cross-compound, which is rather similar in the fundamental features of design to the American Corliss engine, as will be seen from Fig. 11. A feature which differentiates it from American practice is the connection from the main crank-pin to the air pump; one end of a sort of vertical walking-beam projects above the floor near the cross-head guide and a connecting-rod leads from this arm to the crank-pin of the engine, as may be seen from the engraving. A modified form of the familiar Corliss valve is used.

In this same section of the power house is a tandem-compound engine by Van den Kerchove, of Ghent, in which vertically moving balanced piston valves are employed, placed close to the cylinder ends and on the vertical center line of the engine. The steam valves are actuated by a releasing gear and closed by strong steel springs; the shock of closing is taken up by air cushions, each valve being provided with a dash-pot. The cushioning is adjustable in the usual manner by varying an outlet in the bottom of the dash-pot. The use of balanced valves has enabled the builders to employ remarkably light connecting rods from the eccentrics and the governor shaft to the valve levers. The high-pressure cylinders are double steam-jacketed, like steam entering the outer jacket and passing thence to the valves, and entering the inner jacket from the end chambers. The jacket of the low-pressure cylinder constitutes a receiver, as the exhaust steam from the high-pressure cylinder passes into it before reaching the low-pressure valves. The high-pressure cylinder is 24 13-16 ins. in diameter and the low-pressure cylinder is 43 ins. in diameter; the stroke is 47¼ ins. The rated output of the engine is 500 horse-power. The engine drives a revolving-field alternator built by the Compagnie Internationale d'Electricite. There are 72 magnet poles with square pole-shoes, bolted to the rim of the fly-wheel, as shown in Fig. 12.

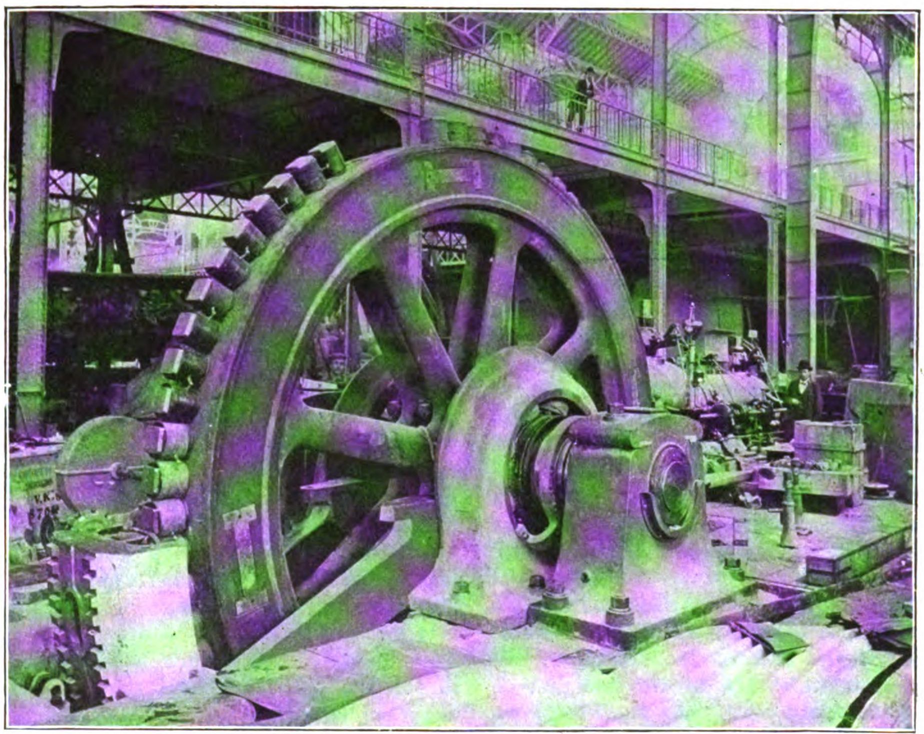


FIG. 12.—REVOLVING-FIELD ALTERNATOR OF THE COMPAGNIE INTERNATIONALE D'ELECTRICITE.

The armature frame is cast in four parts, two being bolted together to form the upper half and two for the lower half, while the laminated armature core is clamped between the opposing inner faces. The armature supports consist of ring-shaped pedestals surrounding the shaft and bolted to the central foundation, and the hub of the armature frame rests upon a turned cylindrical surface on the inner side of each support. This construction allows the rotation of the armature for purposes of inspection or for repair of coils, a small motor being used for turning the frame, by means of worm and spur gearing. The same machine is used for turning either the flywheel or the armature, motion being imparted through spur gears in the first case, and through a chain connection in the second case. To prevent any movement of the armature frame by reaction against the revolving field, the former is normally held in position by bolts passing through lugs into anchors in the foundation.

The armature pedestal on the outer side serves the double purpose of support for the stationary part of the alternator, and field frame for the exciter, which furnishes a maximum current of 180 amperes at 120 volts. The speed of the engine and generator is 83½ r.p.m., giving a frequency of 50 cycles per second. The alternator is a three-phase machine and supplies current at 2200 volts, the primary distribution voltage.

Annual Convention of the Northwestern Electrical Association.

The Northwestern Electrical Association held its summer convention at Chain o' Lakes, Waupaca, Wis., on June 26th, 27th and 28th. The convention was opened by the president, Mr. Pliny Norcross, who spoke in highly complimentary terms of the attractive locality at which the association had convened.

At the first afternoon session a paper on "The Advantages of Recording Wattmeters on Switchboards" was read by W. W. Bean, of St. Joseph, Mich. He called attention to the fact that the use of recording wattmeters in central stations enables a station manager to check the efficiency of operation throughout the plant from the fire room to the switchboard.

Mr. F. A. Copeland, of La Crosse, in the ensuing discussion, said that the plant with which he is connected is supplied with recording ammeters and that the discrepancy between their record and that of the individual consumer's meters ranges from 20 to 35 per cent. Mr. L. A. Ferguson said that on account of the regularity of the voltage, wattmeters were not used in the Chicago Edison plant, but that it was evident that in railway plants, where the load and voltage fluctuate considerably and rapidly, switchboard wattmeters were a necessity if an accurate record of the load was to be had. He stated that the difference between the readings of the station recording wattmeters and the individual consumers' wattmeters in large Edison stations has been found to be from 18 to 20 per cent and in alternating-current stations sometimes went as high as 50 per cent. In a direct-current station he said 25 per cent discrepancy should be considered a large figure.

The discussion of station wattmeters and output naturally led to a consideration of the cost of production, in the course of which Mr. Grover said that he had found the cost at his plant to be 0.8 cent per kilowatt-hour. Mr. Copeland gave the cost at his plant as about one cent per kilowatt-hour, using Youghiogheny lump coal and running four condensing engines, one of which is a compound engine used only during the peak period.

Following the discussion of Mr. Bean's paper, Mr. W. H. Edgar read a paper on "Wet Steam," in the course of which he stated that he did not believe foaming was caused by mud or dirty water, but thought it was due to the soda which is contained as a rule in any water containing mud. There might be a great excess of lime and magnesia in solution in the feed water, but when the water is heated in the boiler the lime and magnesia are thrown out of solution into suspension, and consequently there is no action in the way of foaming due to their presence in the water; on the contrary, soda always remains in solution. Ninety per cent of the waters used in boilers throughout the country contain considerable lime and some soda, and nine out of ten boilers are treated with some salt of soda with the same result that is obtained when well water is used where the soil contains sulphate of soda.

If absolutely dry steam could be obtained, pure mineral cylinder oil could be used without any admixture of animal oil whatever. The condensation washes off the mineral oil, necessitating compounding with animal oil to give it the adhesive property necessary for cylinder lubrication. In a certain railway power house they condemned the cylinder oil and sent it back repeatedly month after month, and finally got up to using about 33 per cent of tallow in the compounding. They were using soda ash in the boilers, and the more soda ash they used the more moisture they had in the steam; and the more moisture was carried over into the engine, the more soda came over with it to cut the animal oil, saponifying it and giving a great deal of trouble before they found out where the trouble lay. A saturated solution of soda ash would contain 40 per cent of soda ash when it begins to cake; with salt there would be a 35½ per cent saturation before it would begin to cake. All sodium salts remain in solution until the water is saturated and then cake, and always cake at the hottest part of the boiler. It is common in Kansas, in New Orleans and along the seacoast where they use salty water, to find the tubes buckled and sheets bagged on account of the salt.

In response to a question by Mr. McMaster as to the method of determining whether there is an excess of soda in the feed water, Mr. Edgar said that an analysis of feed water was the only accurate method. In San Francisco he said they test by taste, letting the water go until they can taste the salt; then they look for a leak in the surface condenser. Mr. W. H. Schott, of Chicago, brought out the point that in many cases wet steam was due to the water being carried too high in water-tube boilers, and that wherever soda ash is used as a purgent violent foaming will result.

On Wednesday the morning session was opened by a paper on "Storage Batteries for Small Stations," by Mr. Louis A. Ferguson. In considering the advisability of using a storage battery he said the relative cost of the battery as compared with that of engines, boilers and dynamos of equal capacity must be first taken into account. The cost of a storage battery is dependent not only upon the maximum energy to be supplied at any one time, as in the case of a generating equipment, but also upon the length of time that the battery is required to do its maximum work—in other words, its kilowatt-hour capacity. Therefore, if the characteristic of the curve is such that the average duration of the peak is more than 1½ hours, then the initial cost of a generating equipment to take care of this peak will be less than that of a storage-battery equipment capable of doing the same work. If the peak of the load curve is of less duration than 1½ hours, then the initial cost of the battery would be less than that of steam and electrical apparatus necessary to take care of the peak.

The curve, Fig. 1, shows the cost and capacity of a battery at various rates of discharge ranging from one to eight-hour discharge periods, the battery having a capacity at the eight-hour rate of 11,200 ampere-hours or a current rate of 1400 amperes. The cost of a battery of moderate size is approximately as follows: Discharge period of one hour, $80 per kilowatt; two-hour discharge period, $116 per kilowatt; three-hour discharge period, $160 per kilowatt; five-hour discharge period, $240 per kilowatt; eight-hour discharge period, $320 per kilowatt. These figures include switchboard equipment, end-cell switches, and the battery installation complete, but do not include building investments; the straighter curve in Fig. 1 is based on these figures. An average price for boilers, steam engines, steam piping, generators, chimney and switchboard is $100 a kilowatt.

The question of depreciation on the two classes of apparatus, economy of operation and the value of each class as a reserve or guarantee to the customer of uniform and reliable service, must also be taken into account. The operating expenses incident to the use of storage batteries are comparatively small in a moderate-size station, so that no additional labor would be required on account of the use of the battery beyond that ordinarily employed in the station. The amount of material necessary is almost negligible; distilled water is perhaps the principal item and perhaps once or twice a year additional sulphuric acid will be required. The yearly energy efficiency of a storage battery operated under ordinary central station conditions would probably not exceed 65 per cent.

Fig. 2 shows the work done by a storage battery on a summer day; this battery was kept connected to the system at all times during the 24 hours, taking its charge from the generators between midnight and 7 o'clock in the morning, when the load is lightest. Ordinarily the day load curve would have no decided peak, but the curve shown here has a peak occurring between 11 and 12 o'clock in the day due to a thunderstorm which overclouded the city and caused the load to be thrown on very suddenly. Fig. 3 shows the work done by a storage battery on a winter day, the battery being charged as in the previous case between midnight and 7 o'clock in the morning and discharged at a high rate during the peak period which occurs between 4 and 6 o'clock in the afternoon. The curve, it will be noticed, shows the battery discharged not only at the time of maximum peak, but also for an hour or so after the peak has begun to drop, and this illustrates one advantage of the storage battery which has not so far been mentioned.

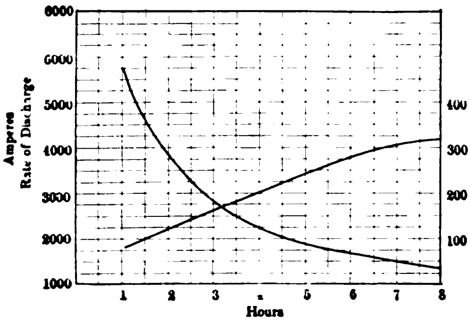


FIG. 1.

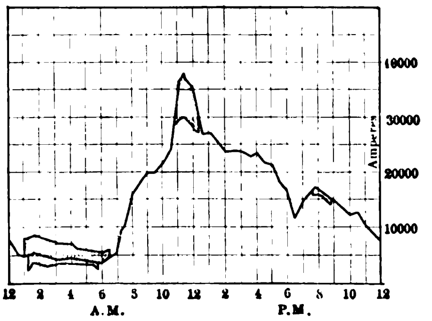


FIG. 2

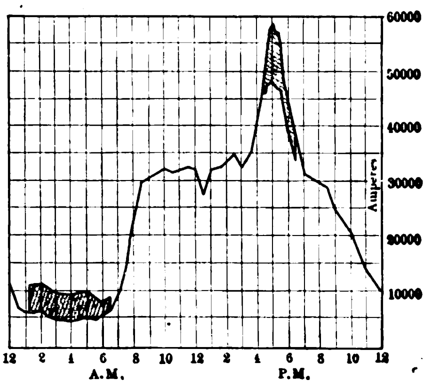


FIG. 3.

It very often happens in any system of distribution that feeders are of unequal length and carry unequal loads. The pressure, therefore, which is maintained at the bus-bars of the station is limited by the safe carrying capacity of the shortest feeders. When the short feeders are fully loaded the long feeders will be overloaded, and if the bus-bar pressure is raised sufficiently to load the long feeders, then the short feeders would be overloaded. To obviate this difficulty, the storage battery is exceedingly useful, and in determining the relative cost of storage battery and steam and electrical generating equipment, this important advantage of the storage battery must be considered and reduced to its equivalent in money value and credited to its original cost.

In order that the battery may provide for the equal or economical loading of feeders, it is equipped with two or more end-cell switches, so that it may be operated at two or more potentials. The short feeders are then connected to the main bus and the long feeders to an auxiliary bus. One end-cell switch of the battery is connected to the main bus of the system, and the other end-cell switch to the auxiliary bus. In this way the battery provides two potentials, one at perhaps five to ten volts higher than the other, and during the time of peak of the load on the system the long feeders are operated from the auxiliary bus, the battery supplying all the current required by these long feeders, and the pressure throughout the system is maintained at equality.

Fig. 3 illustrates this point very well, the battery being kept on both main and auxiliary bus-bars from 4:15 until 5:45 in the evening, at which time it is disconnected from the main bus and retained on the auxiliary bus until 6:30 o'clock, the long feeders during all this time being kept at full load, and the investment in copper required to do this work being entirely saved, the work being accomplished with a comparatively small initial investment in end cells and end-cell switches.

Of course, the loss of pressure by this means is somewhat greater than if the feeders were connected to the main bus, but as the loss of energy occurs during a very short period of time, the actual loss of money in operating represented thereby is practically negligible.

Conditions may exist also in certain stations where it is desirable to give a 24-hour service and where the load is appreciable only during the time from dusk until midnight, and during the remaining 16 hours of the day the load is so small that the cost of operating expenses for steam and electrical equipment would be so high as to make the use of the storage battery to take care of this long period of minimum load very desirable. In this case the generating plant would be started in time to charge the battery fully, so that it might take care of the station's load during the entire period of minimum load.

The storage battery is exceedingly useful in small stations where the load on the station at certain times is very light and where motors are supplied from the same system of mains. Under these conditions genrators are extremely sensitive, and do not maintain the pressure constant under the varying conditions of load, while the use of a storage battery keeps the pressure on the lines constant at all times, and variations which would otherwise come from short-circuits and sudden variations in motor load disappear absolutely. The advantage of uniformity of pressure is especially desirable in small central stations, where the cost of lamp renewals is an important feature, since by the use of the storage battery the life of the lamps is prolonged and the cost of lamp renewals thereby largely reduced.

It is difficult to lay down a set of laws which might be used in the determination of the usefulness of a storage battery, but it is probably safe to say that there is no economical advantage in the use of a storage battery in a lighting system where the average width of the peak of the load is more than from 1½ to 2 hours in duration, although the battery may have a commercial advantage in insuring the customers of the central-station company a thoroughly reliable service, with uniform quality of illumination.

In the discussion which followed the reading of his paper, Mr. Ferguson stated that the diagrams were taken from the Chicago Edison stations, but in order to apply them to small plants all that was necessary was to drop off one or two zeros, the operation of storage batteries in small plants being relatively the same as in large ones. He also pointed out that very few small stations could use storage batteries to advantage, particularly small stations in which the peak of the load curve was of considerable duration. For small stations when the storage battery company gave a guarantee, Mr. Ferguson stated that a depreciation of 9 per cent could be assumed.

A paper on "The Losses in Small Lighting Plants" was next read by Professors B. B. Swenson and A. A. Richter. The authors pointed out that in a large number of cases small plants as well as large ones would be greatly benefited by practical tests properly conducted and interpreted. Frequently such a test demonstrated that it would be a good investment to "scrap" certain apparatus and replace it with a new and more modern equipment. In many cases the saving effected in one or two years will more than pay the cost of making the change. In order to illustrate the importance of these statements the writers presented results taken from some tests recently made by them on a combined lighting and pumping plant. The boiler room contained two return-tubular boilers, each of

43-h.p. capacity, and the engine-room equipment comprised a 125-h.p. Ideal engine belted to a 90-kw. 2200-volt Westinghouse alternator.

The flue-gas analysis showed an average of 6.57 per cent of carbon dioxide. This result is too low, and shows that too much air is admitted to the furnace. It was found that during the time of light load and after starting boiler No. 2, a test of the flue gases showed but 2.3 per cent of carbon dioxide, while during the time of heavy load (8.15 to 10.15 p. m.), there was about 8 per cent of carbon dioxide. This last result was fairly good, although it can be improved upon. With very careful handling of the dampers and fire an average result of from 8 to 10 per cent can easily be obtained.

The engine and alternator are both of very recent design, and, if they were operated at anywhere near full load, would leave little to be desired in this direction. Load and efficiency curves of the engine and alternator are shown in Fig. 4. Electrical and indicated horse-power data are given as vertical distances and time as horizontal distances, so that the electrical and indicated horse-power can at once be read off for any time of the day.

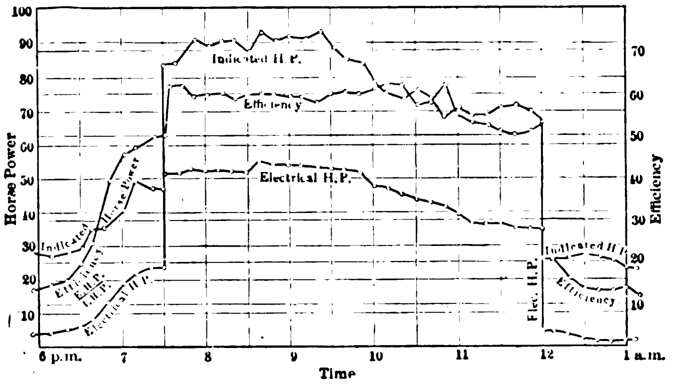


FIG. 4.

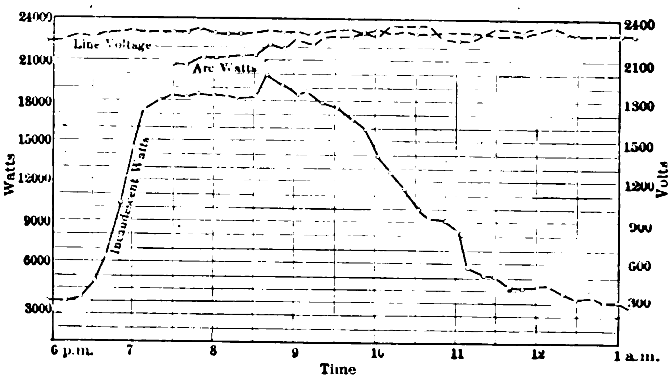


FIG 5.

The average electrical horse-power is but 33.2, while the average indicated horse-power is 62.3. The maximum electrical horse-power is only 56.2, and the maximum indicated horse-power is 93.2. The minimum electrical and indicated horse-power are 3.6 and 24.8 respectively. These figures show to how great an extent the unit is underloaded. The low efficiency, which is due to this cause, averages 53.2 per cent, reaching a maximum of 62.8 per cent at 10.10 p. m., and having a minimum value of about 14 per cent. This means that on the average 53.2 per cent of the power generated in the engine cylinder reaches the switchboard; the remainder, 46.8 per cent, is lost in the transmission. When the lighting unit is in operation all night, this loss is increased to a considerable extent.

The horse-power and efficiency curves show the very light load on the electric station during the earlier hours of the evening and after the arcs are taken off at night, the efficiency of the unit falling as low as 13 per cent. It is evident that a smaller unit, if installed, will decrease the cost of operation to a considerable extent, besides furnishing a duplicate outfit. In case of accident to one of the units, the station will still be able to furnish light to its patrons.

On the third and final day of the convention a paper sent in by Prof. Geo. D. Shepardson, who was absent, entitled "Why Some Municipal Plants Do Not Pay," was presented, and the Association unanimously decided to print it in the transactions. The paper pointed out that the principal cause of agitation in favor of municipal ownership is the circulation of incorrect figures as to the actual cost of operating existing municipal plants, which are almost invariably too low. Another potent cause is the general belief on the part of the public that electric companies are making enormous profits, whereas the painful fact is that probably few of the smaller companies are really earning any dividends. Should the municipal and private plants adopt correct methods of keeping records and making them public so that it would be generally known what the cost of operation really is and how small the net earnings of private plants are, the agitation for municipal ownership would probably die a natural death in a few years.

Statistics relating to the municipal and private lighting plants in Minnesota were presented, which showed that in 1894 there were 10 municipal plants and 35 private ones and in 1900 the municipal plants had increased to 53 and the private plants to only 63. It was explained that these figures were not so significant as they might at first seem for the reason that many of the municipal plants are located in towns too small to justify putting in private plants except in connection with some other business, and all of the lighting plants in the larger cities are privately owned central stations. Instances of mismanagement of municipal plants were cited showing that the efficiency of such plants was much less than might be expected by the claims made for them. Professor Shepardson emphasized the disadvantages of political control, including appointments of employees by favor instead of by merit, and said that the state of the records kept in some municipal plants was almost incredible, some instances being given where lights were used without any record being made. In one instance municipal authorities were beguiled into paying a higher price for a new lot of lamps because they "had more watts than the kind formerly used." In conclusion Professor Shepardson expressed the opinion that arguments in favor of and against municipal ownership should be modified by the personal equation.

On Thursday afternoon a paper on "Street Lighting," by Mr. H. H. Wait, was presented, an abstract of which will be found in another column. After the transaction of some routine business the convention adjourned until June, 1901.

A NOTE ON THE USE OF CONDENSERS IN POWER STATIONS.

BY R. C. CARPENTER.

The use of condensing engines gives a saving as compared with non-condensing engines of the same class of approximately 30 per cent; this saving is in every case due to the approximate removal of atmospheric pressure from the exhaust side of the piston, the action being equivalent to increasing the mean pressure on the engine piston by whatever amount the atmospheric back pressure is reduced.

The writer some years ago made a test of a large power station using compound non-condensing engines, and this past year he repeated the test on the same station, with many of the same engines in use, but all arranged to work condensing. The steam per indicated horse-power as shown by the first test was 30.6 pounds; by the last test it was 24.4 pounds per hour. The results of the tests, quoted in my previous article, show that the value of a vacuum is equivalent to a large per cent of the fuel consumed without it and consequently a large outlay is in most cases justified in order to secure it.

Condensers are of two kinds, jet and surface. In the jet condenser the condensing water is sprayed into a chamber which receives the exhaust steam and the condensation is performed by direct contact of the condensing water and the steam. In the surface condenser the water is made to circulate through tubes, which are arranged in a chamber into which the exhaust steam is discharged. The condensing water is by this method kept from mingling with the exhaust steam. The water of condensation is removed by an air pump, which also reduces or removes the atmospheric pressure, causing and maintaining the vacuum.

Under some conditions the surface condenser is preferable to the jet condenser. It permits the use of impure water, not fit for boiler feed water, for condensing purposes and is the system almost invariably employed on shipboard, where salt water is used for condensing purposes while the condensed steam is employed for feed water. This system is not used to any great extent on land, although its success on ocean vessels proves that under certain conditions the method is practicable and economical. The objection to this method of operation is due to the fact that the greater portion of the lubricating oils which feed into the cylinders of the engine passes through the cylinder into the exhaust. These oils exert a detrimental effect on the boiler, as they are likely to settle on the sheets or tubes and cause burning or blistering of the metal. A thin film of grease is a non-conductor of heat and also reduces the efficiency of a boiler seriously; in fact, it is much more harmful than a very thick scale of carbonate of lime.

So far as I am able to determine by tests, a lime scale, even of great thickness, has no appreciable effect on the efficiency of a boiler, as in a test which was conducted by myself the results were practically as good when the boiler was thickly covered with lime scale as when perfectly clean. I have seen many published statements in which the contrary opinion was emphatically expressed, but observations and experiments have shown that any scale porous to water has little or no detrimental effect on economy of the boiler. There is, I think, good philosophy for this statement; the heating capacity is affected principally by the rapidity with which the heated gases will surrender heat, as the water and the metal have capacities for absorbing heat more than a hundred times faster than the air will surrender heat.

This being the scientific statement of the case, it is evident that any deposit which curtails slightly the capacity of absorbing heat on the water side has very little effect either on total capacity or on efficiency. A thin film of grease, being impermeable to water, keeps the latter from contact with the metal and generally produces disastrous results. There are, however, many ways of preventing grease from entering the boiler, or if it should enter, of neutralizing its effect. These methods have been tested to such an extent that there is now no longer danger of bad results if proper precautions are taken, and hence no reason why the surface condenser should not be used extensively.

Abstracts from Foreign Contemporaries

Frictionless Motor Meter.—Although Mr. William Stanley's ingenious meter is well known in this country, a description of the Evershed meter, which in the main point is similar to the Stanley meter, may be of interest to the reader, as both meters differ greatly in the details. The description is abstracted from a paper which was recently read by Mr, S. Evershed before the British Institution of Electric Engineers, and was published in recent issues of London electrical contemporaries. Like Stanley, Evershed endeavors to remove the errors of a motor meter due to friction, and to accomplish that mostly by means of a magnetic suspension. There are three causes of error due to friction in an ordinary motor meter: the friction of the axle bearing, the friction of the brushes on the commutator, and the friction of the counting train and gear connecting it with the motor spindle or shaft. With an ordinary vertical spindle, the friction of the spindle bearings is nearly all due to the bottom or step bearing, which is usually a rounded steel point resting in a jewel cup; in the Evershed meter the pressure of the shaft on the bottom bearing is reduced to a few grammes by magnetically suspending the shaft, armature and brake; a top bearing is entirely dispensed with, the spindle being "magnetically pivoted." The brush friction is enormously reduced by the use of a novel form of commutator, having elastic segments against which the edges of two light and freely pivoted wheels roll to act as brushes, as shown in Fig. 1.

The friction of the train is entirely removed as a source of error, the train being driven by a simple electromagnetic device, whose speed of working is controlled by the speed of the motor, although there is absolutely no mechanical connection between them. These means have sufficed to reduce the friction from a value between 300 and 400 dyne-cms. to less than 3 dyne-cms., and Mr. Evershed believes that the limit has not yet been reached. Experience has proved that one of the worst troubles with all forms of suspension was caused by the magnetic axis not being absolutely coincident with the rotational axis, the latter being determined by the pivots. If the top pivot is removed, the shaft or spindle is free to center itself in a magnetically symmetrical fashion, and it will then rotate about the magnetic axis. Any directional movement due to the spindle and suspending pole not being perfect figures of revolution will be enormously reduced by diminishing the diameters of spindle and pole; and with diameters not much exceeding 0.2 in., the supporting pole has no measurable directing influence upon the spindle.

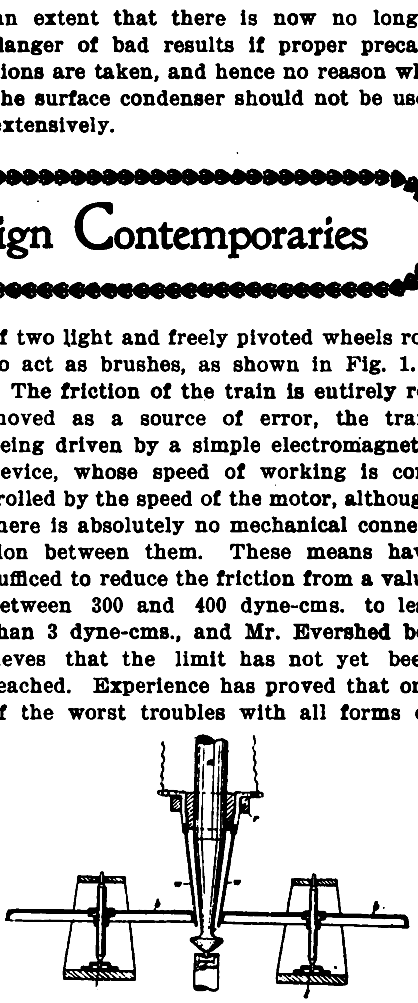
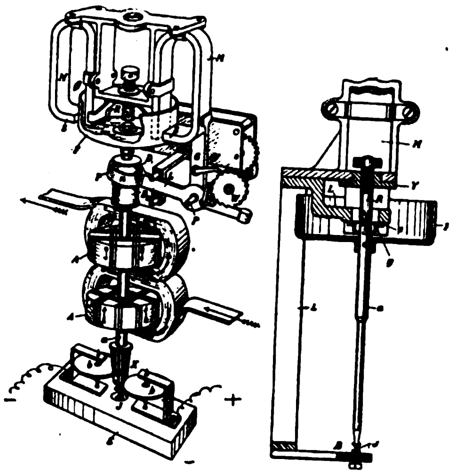


FIG. 1.—FLEXIBLE COMMUTATOR.

To prevent the spindle from accidentally coming into contact with the supporting pole, a thin plate of non-magnetic metal is interposed between them (indicated in Fig. 3 above by the horizontal thick black line e between N and S); it is fixed immediately above the end of the spindle, leaving a very small clearance. The supporting pole is adjusted until nearly the whole of the pressure on the step bearing is relieved. If the pressure is reduced to zero, a slight shake will jerk the spindle up until it rests against the plate, where it will remain, since the upward attracting force increases as the space between shaft and supporting pole diminishes. It is, therefore, necessary to leave a few grammes of weight unbalanced so that there is sufficient gravitational force downward to pull the spindle off the end-plate, should it happen to rise into contact with it. In a discussion of the essential points in magnetic suspension of meter axles, Mr. Evershed arrives at the following essential principle; the induction density in the magnetic devices used for support must remain absolutely constant during the rotation of the shaft. This shows that an unsymmetrical bipolar arrangement would not serve, but that the attracting pole must be a figure of revolution with its axis coincident with the axis of rotation. The device adopted by him consists simply of a round iron rod, R, fixed with its lower end immediately above and in line with the iron spindle. Fig. 3 shows a section through the magnetic pivot. The shaft has a hard steel point at its lower end resting in a jewel cup, J; the upper end is maintained in position by the magnetic attraction of the pole, N, of the iron rod, R, which is magnetized by the brake magnets, M, through an iron yoke, Y. The distance between R and the end, S, of the shaft is adjusted by screwing R in the yoke Y until the vertical force nearly suffices to lift the whole weight of the armature, brake and other parts attached to the shaft as mentioned above.



FIGS 2 AND 3.—DETAILS OF METER.

Electrolytic Bleaching.— Electrolytic bleaching is already one of the most successful applications of electrochemistry; and it is very probable that the tendency now observed in textile mills of many countries to adopt electric transmission of power will hasten the development of the electrolytic bleaching industry. It is evident that when a large factory already possesses an electrical generating plant for lighting and power purposes, the use of a fraction of this power for the preparation of bleaching solutions, will be a comparatively simple matter; in such cases the addition of an electrolyzer and two storage vats will be all the additional plant required. For this reason an abstract of an elaborate article of Mr. John B. C. Kershaw on electrolytic bleaching, in a recent number of the London "Electrician" may be of interest. The principle of electrolytic bleaching depends upon the production of hypochlorite of sodium or magnesium, when sodium or magnesium chloride solutions are decomposed by the electric current. The conditions requisite for the production of bleaching solutions by electrolysis are therfore: insoluble electrodes, no diaphragm, low temperature of the electrolyte, and rapid circulation of the electrolyte from the cathode toward the anode. The forms of cell which have been devised to attain these conditions have naturally many features in common, and it is only in minor details of construction that they differ one from the other. Mr. Kershaw describes the electrolyzers of Hermite, Stefanow, Kellner, Woolf, Corbin and Vogelsang. As Mr. Kershaw gives some figures on the Kellner process, we restrict this abstract to a description of the Kellner electrolyzer. In its most recent form it consists of an earthenware cell containing the electrodes, communicating with a centrifugal pump and an enameled receiver, in which is placed a cooling pipe coil connected with the water supply. The salt solution is kept in continuous circulation by means of the pump through the electrolyzing cell and the cooler until the desired strength is attained. The electrodes are formed by winding platinum-iridium wire upon glass plates, and are stated to be highly efficient.

The Kellner electrolyzer is said to be used at some places in Austria, Norway, Hungary, Switzerland and at many places in Southern Russia. Actual trial has shown that 114 amperes at 112 volts for 3 hours yielded 12 lbs. of active chlorine, which is equivalent to 4.3 horse-power-hours per pound of active chlorine. For a comparison of the cost of the old bleaching process using solutions prepared from bleaching powder, with the new bleaching process by the electrolysis of common salt, some figures are given representing the costs of actual trials. One trial was made with 6160 lbs. of light calico goods for dyeing and printing; with the electrolytic method the total cost of chemicals was $1.05, with the older method with bleaching powder it was $3.47. Another trial was made with 7590 lbs. of heavy calico for white goods; with the electrolytic method the total cost of chemicals was $2.11, with the old method with bleaching powder it was $5.26.

Polyphase Traction.—In the May issue there appeared in these columns a description of the 65-mile three-phase railway at Colico, Italy, with high-tension transmission and transformer substations for reducing the pressure to 3000 volts, at which voltage the current is supplied to the three-phase motors on the cars. According to an article by Mr. E. K. Scott in a recent issue of the London "Electrical Review," the plans of this line, details of the cars, etc., are now exhibited at the Paris exposition; the line itself will not be ready for use before the end of 1901, but an experimental line of one mile has been erected by Ganz & Co. at Budapest, on which all the details are being carefully worked out.

In a recent number of the "Elektrotechnische Zeitschrift" Mr. Walter Reichel describes experiments made since 1898 by the Siemens & Halske Co. of Berlin on an experimental line, the purpose being to study a system of polyphase transmission at 10,000 volts, the currents to be taken off by means of sliding contacts and reduced by transformers on the motor cars to a lower voltage for supply to the polyphase motors. The principal results of these trials are that it was proven to be feasible to take the currents off by sliding contacts at 10,000 volts and at speeds up to 37 miles an hour. It is well known that the ordinary under-running trolley wheel does not maintain uniform contact with the trolley wire at speeds above 25 miles per hour; the design of a sliding contact practical for higher speeds was therefore the main object of the experiments. The officials of the villages where the trial line was erected required a system of safety wires to be drawn below the trolley wires, in order to prevent an accident in case a wire should break; therefore a contact sliding along the under side of the trolley wire could not be tried. Two other systems were tried: sliding contacts making contact with the upper side of the trolley wire, and lateral sliding contacts; the latter, which are shown in Fig. 4, proved to be the better. Trials were made with three line potentials—750, 2000 and 10,000 volts—and at various speeds up to 37 miles an hour. The sliding contacts were found to work better at 10,000 volts than at a lower voltage, and proved to be entirely practical for the purpose.

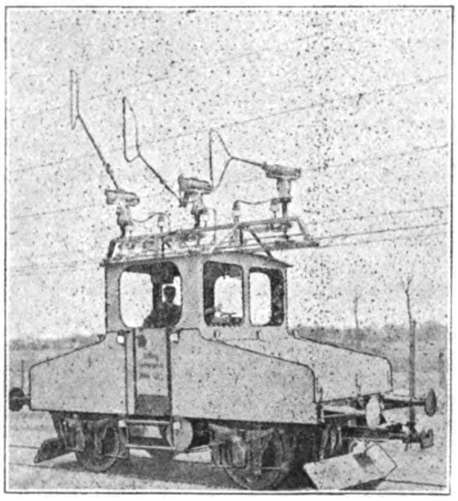


FIG. 4.- THREE-PHASE LATERAL TROLLEY CONTACTS.

Schaefer System of Wireless Telegraphy—For some time in Germany and Austria experiments have been made with the Schaefer system of wireless telegraphy. From a note of the London "Electrician," taken from German daily papers, we gather that an apparatus, with a wire 205 ft. in height, has been put up for the North German Lloyd Company at Kaiserhafen, to effect communication between Bremerhafen, a lighthouse at Borkum, and a fireship; and furthermore that it hoped to signal successfully between Heligoland and Bremen, a distance of nearly 100 miles, and that the large Lloyd steamers are gradually all to be equipped with Schaefer apparatus. It appears that the characteristic feature of the Schaefer system is the device used instead of the coherer. About this device Dr. W. A. Nippoldt read a paper before the Technical Society of Frankfurt, which is abstracted in the "Elektrotechnische Zeitschrift." The device consists of a metallic film on a glass plate, the film being cut into parts; the normal resistance is 50 ohms and it increases to 5000 ohms under the influence of electric waves. The reasons for this phenomenon have not been found so far. Formerly it was assumed that electrolytic processes in the cuts were in question and, in fact, in very moist air metallic bridges could be observed by the miscroscope, and these bridges were destroyed by electric waves; but in later experiments it was found that the same increase of resistance was obtained in an entirely dry atmosphere and even in a vacuum. In air the sensitiveness of the apparatus depends upon the dampness of the air, while the sensitiveness is entirely constant in a vacuum. The metallic layer was formerly a sheet of tinfoil but now silvered glass is used, the silver being cut into parts by sharp scratches; the sum of the widths of all scratches is only a few hundredths of a millimeter. The experiments made so far appear to show that the sensitiveness of the apparatus increases with the width and the number of the cuts to a certain point, and then decreases.

Dynamo Brushes.—In a recent issue of the "Elektrotechnische Zeitschrift" Mr. G. Dettmar calls attention to the heating loss in dynamo brushes. This loss has become more important in recent years, since carbon brushes have come into very general use, for which the loss is obviously greater than for copper brushes. It is, therefore, worth while to study the best size of the brushes; the best pressure upon slip-rings or commutators and the best current density. He has made an elaborate series of tests in which he investigated the contact resistance between brushes and slip-rings or commutators and from which he draws the following practical conclusions. Under average conditions the most favorable pressure of copper gauze brushes upon slip-rings is about equal to the usual normal pressure; at high speeds the brushes should touch the slip-rings very lightly only, and the more so, the smaller the current density. To press the brushes down hard against the slip-ring is entirely wrong; the contact resistance would thus be somewhat diminished, but while something would be gained in this direction, much more would be lost by the increase of the friction loss. For carbon brushes, under average conditions, the most favorable pressure is about 32 ounces per square inch, which agrees with the usual pressure; also for carbon brushes the rule should be followed to make the brushes touch the slip-ring only lightly, and the more lightly the smaller the current density. Regarding the best current density he finds that the ideal value for copper gauze brushes would be above the limits which can be used in practice; it should, therefore, be as large as possible. For carbon brushes the best current density is about that which is used in practice. In the second part of his paper he deals with brushes upon commutators and reaches the following conclusions. Copper gauze brushes should touch the commutator as lightly as possible. For carbon brushes, at normal speed and greater current density, the best pressure is about that used in practice. With copper gauze brushes only at low speeds is it possible to use the theoretically best current density (which is, for instance, 92 amperes per square inch for a speed of 10 feet per second), while at higher speeds the current density should be as high as possible. For carbon brushes the theoretically best current density is about that used in practice.

Measuring the Current in a Distant Station.—In cases where a network is supplied with current from two different stations, it is often desirable that the switchboard attendant at one station knows the current supplied by the other station. This can, of course, be provided for by inserting resistance in the lines at both stations and leading the wires from the terminals of each resistance to an ammeter in the distant station; four auxiliary wires are therefore necessary for measuring purposes and it is evident that this method is rather clumsy and uneconomical. Dr. Michalke and Dr. Martienssen describe in a recent number of the "Elektrotechnische Zeitschrift" three methods which necessitate the use of only one auxiliary wire.

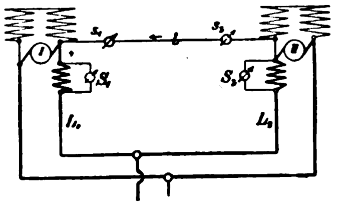


FIG. 5.

The first of these methods is shown in Fig. 5, where I and II are the two stations, L_1 and L_2 the feeders from the stations for supplying the common network, l the auxiliary wire; s_1, s_2, S_1, S_2 are ammeters. It is thus possible to measure in station I the currents in l and L_1 and to measure in station II the currents in l and L_2; as according to Kirschhoff's law, in a closed circuit containing no acting e.m.f., the sum of the products of resistance and current of all parts of the circuit is zero, there is an equation between the three currents in the three wires l, L_1, L_2, so that if two are measured, the third can be calculated. This method, very simple in its principle, is rather roundabout in practice and requires two ammeters in each station.

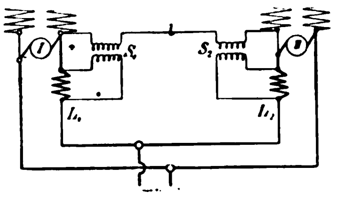


FIG. 6.

The second method, described by the authors and illustrated in Fig. 6, requires one instrument only in each station; it is based upon the principle of the differential galvanometer. Each of the instruments has two windings, one producing a field proportional to the current in l, the other a field proportional to the current in L_1 or L_2 respectively. The ampere-turns of the instruments can be chosen so that the field produced in S_1 is proportional to the current in L_2 and the field produced in S_2 proportional to the current in L_1. This method is simple in practice, but it requires specially designed instruments.

The third method, illustrated in Fig. 7, is the simplest. Here, w_1, w_2, W_1 and W_2 are resistances and S_1 and S_2 are ammeters. It is required that S_1 shall indicate the current furnished by station II and S_2 the current furnished by station I. This can be accomplished by properly choosing the resistances w_1, w_2, W_1 and W_2. If station II gives no current, the e.m.f. at the terminals of S_2 must be zero, which is the case if w_1 is equal to the product of w and W_1 divided by the resistance of L_1, where the resistance of the auxiliary wire l between A and B is supposed to be large compared with the resistance of the feeder L_2. An analogous equation is obtained for the resistance w_2. If w_1 and w_2 are chosen in this way, and both stations supply current, the indication of each ammeter depends only upon the current furnished by the other station; that is, the current going through the ammeter S_1 is equal to the current furnished by the station II, multiplied by a constant coefficient which is a simple function of the different resistances.

Bremer Arc Light.—The Nernst lamp is said to burn very well at the Paris exposition, so that it may be hoped that this lamp with its extraordinary economy of working will soon be introduced into commercial use. An analogous progress has just been announced in arc lighting. In the recent annual convention of the Union of German Electrical Engineers Prof. W. Wedding gave an account of tests of a new arc lamp, devised by Mr. H. Bremer; the paper is reprinted in a recent issue of the "Electrotechnische Zeitschrift," from which we take the following information. The feature of Bremer's invention is said to be that if to the carbon are added 20 to 50 per cent of non-conducting metallic salts, for instance, compounds containing calcium, silicum, or magnesium, a far greater economy of working is obtained. Prof. Wedding has made tests of two direct-current lamps and one alternating-current lamp.

In the direct-current lamps only the positive carbons were prepared with a compound containing calcium. With a small direct-current lamp without a globe he obtained an hemispherical intensity of 4320 candles for an average power consumption of 546 watts, i.e., 0.126 watt per candle; for the same lamp with a globe the hemispherical intensity below the horizon was 2772 candles for 543 watts, i.e., 0.796 watt per candle. A larger direct-current lamp with four arcs without a globe gave an hemispheric intensity of 49,730 candles at 4980 watts, or 0.1 watt per candle; the same lamp with a globe gave an hemispherical intensity of 26,890 candles at 4610 watts, i.e., 0.17 watt per candle. Direct-current lamps of the Bremer type without globes require therefore on the average 0.1 watt per candle. Prof. Wedding says the lowest power consumption he found in other arc lamps was 0.3 watt per candle, while the average value is 0.4 to 0.5 watt per candle. His experiments with alternating-current arc lamps were only preliminary; the result was 0.5 watt per candle, but he believes that the economy of working can be much improved. Furthermore, it is claimed that the light of the Bremer arc lamp is more similar to sunlight than the ordinary arc light; it contains rays of the region of the yellow and red part of the spectrum, and is much less absorbed by a foggy atmosphere than ordinary arc-light rays.

Standard Resistances.—The English papers publish an abstract of a paper read by Mr. R. T. Glazebrook before the British Physical Society, in which he describes three methods which he has employed for building up multiples of a standard resistance, such as a 1-ohm coil. The first method consists in making as accurately as possible three 3-ohm coils. These in

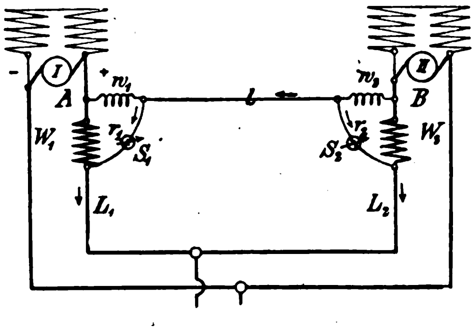


FIG 7.

parallel can be compared directly with the standard by Carey Foster's method. Their resistance in series is nine times that in parallel, and hence an accurate determination of a resistance 9 ohms can be obtained. If, then, this resistance is put in series with the standard, an accurately known 10-ohm resistance is obtained. By a similar process a 100-ohm or a 1000-ohm coil can be built up. The second method consists in calibrating a resistance box. The 1-ohm coils of the box are compared directly with the standard, and the other resistances determined accurately by a building up process, using a subsidiary resistance box. In comparing the high resistances the difference between the two boxes may be so great as to send the balance beyond the range of the bridge. In this case the third method is employed. The equal arms of the bridge are accurately known, and one of them is shunted with a resistance, which need not be accurately known, until the reading is brought back into the bridge's range. The coils chiefly used throughout the experiments are made of platinum-silver.

Some Recent Electrical Patents

An Automobile Controller.—The first controllers for automobiles were cylindrical and resembled closely, on a smaller scale, the controllers commonly used on street cars with the omission of the magnetic blow-outs, which are unnecessary with the smaller powers of automobiles. These cylindrical controllers were driven by pinions meshing with sector gears attached to hand levers. Mr. A. L. Stevens has patented an improved arrangement which has been adopted on the hansoms and broughams of the Electric Vehicle Company. In this controller, a sectional elevation of which is shown in Fig. 1, the handle, which rises beside the driver's seat, is directly connected to the shaft of the controller. As the handle can only be conveniently moved through about 90°, the controller becomes sector-shaped instead of a complete cylinder. In the form shown in Fig. 1 there are five positions, one off, in which the controller is shown, three forward, and one reverse. For each position there is a row of contacts, 17, mounted on an independently detachable wooden strip or bar, 15. These strips are grooved between the contacts to admit stationary barriers, 20, to prevent arcing between the fingers, 24. A roller on the end of the pivoted arm, 45, is held upward by a spring against the teeth, 43, to center the controller squarely in the notches. The operating handle is provided with a catch so that when thrown quickly from any forward running position to the off position it cannot by any inadvertence be carried over to the reverse position, a rotation of the handle being required before it can be advanced to the latter position. The parts are made so that the whole of the controlling cylinder section can be turned over to bring the contacts up for inspection and repairs. Patent No. 650,430.

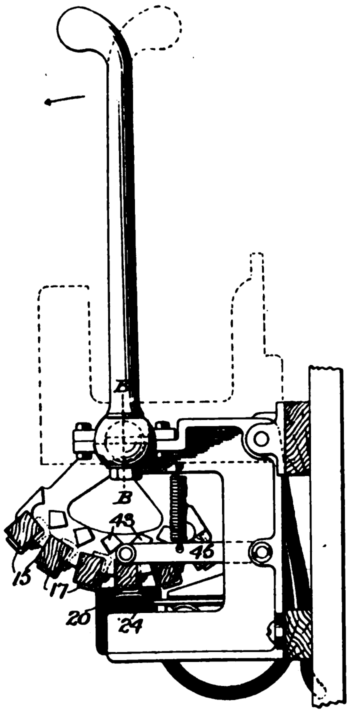


FIG. 1. AUTOMOBILE CONTROLLER

A Means of Preventing Hunting in Rotary Converters.—The commonly used method of preventing hunting or pumping in rotary converters is the application of short-circuited bars to the pole tips of the machine. The two copper bars on the tips of one pole may be short-circuited to each other, forming a complete copper ring around that pole, or preferably the two bars on adjacent tips of two neighboring poles may be short-circuited to each other, forming a loop between the two poles. The General Electric Company has on many machines put out a flat copper bridge or plate between the tips of two neighboring poles. Messrs. H. Geisenhoener and C. D. Knight of the same company have patented an improvement on this device, embracing better mechanical details for rigidly fastening the copper bridge or loop in place in such a way that it will not be readily shaken loose by the vibrations of the machine. The arrangement is shown in Fig. 2, in which 2 and 2 represent the tips of neighboring poles, under which are wedged the jaw-shaped bars, 6 and 6, which are forced into place by the straightening of the curved arms, 7 and 7, by means of the bolt, 8, and nut, 9, the arms serving as a sort of toggle joint to wedge the side bars firmly between the poles. Patent No. 650,677.

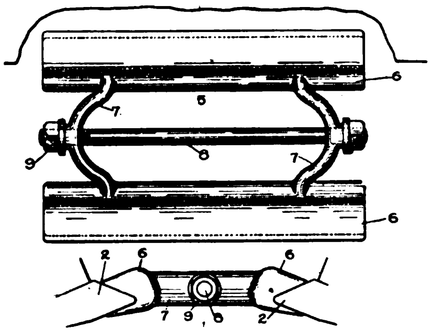


FIG. 2.—POLE BRIDGE.

An Enclosed Plug Fuse.—Mr. L. W. Downes has patented a modification of the D. & W. enclosed fuse such that it can be used in the usual plug cut-outs of the Edison socket type. Fig. 3 shows the details of the plug, from which it may be seen that the usual air space of the D. & W. fuse has been retained in the form of a chamber between two diaphragms, the fuse passing lengthwise from the terminal at the bottom of the plug through the enclosing material and the air space to a plate at the top of the plug electrically connected to the outside shell. The claims cover the combination of all these parts. Patent No. 650,602.

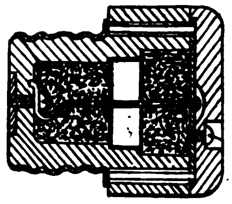


FIG. 3.—FUSE PLUG.

Open-Conduit Electric Railway Construction.—Mr. J. H. Robertson, chief engineer of the Third Avenue Railway of New York City, which was recently absorbed by the Metropolitan system, has patented the form of conduit construction used on the Third Avenue lines. The general arrangement of the parts is shown in Fig. 4. C^1 and C^2 are iron castings riveted to the short piece of steel or rail, C, to form the yoke; D and D^1 are wooden stringers, intended to give elasticity to the track and deaden the sound. The track rails are held to the yoke by means of braces, E and E^1, to which are riveted the tie bars, F and F^1, to hold the slot rails, B and B^1, from closing together. The claims cover the combination of rails, stringers, braces and tie rods, and the combination of stringers and clips, by means of which the rails and stringers are held in place. Patent No. 650,094.

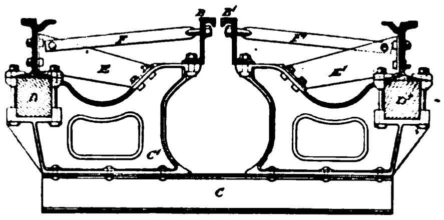


FIG. 4.—RAILWAY CONDUIT.

The Manufacture of Carborundum Articles.—The usual method of making articles of carborundum is to grind up the material, mix it with a binder such as clay, and fire the mixture, the carborundum itself, as manufactured in the electric furnace, not having sufficient cohesion to form a stable article. The binder is sometimes objectionable, as for example, when the articles made with it are to be exposed to a temperature sufficient to destroy it. Mr. F. A. J. Fitzgerald has patented a new method of making carborundum articles in which the carborundum is mixed with any adhesive material which will hold the grains together temporarily, the mass so molded being then heated in an electric furnace to a temperature about equal to that necessary to produce the carborundum. It has been found that when so treated the carborundum will recrystallize and produce a very hard dense mass, occupying substantially the same space as that into which it is compressed, and without substantial loss of material by vaporization except that of the temporary bond. In this way refractory bricks may be made of practically nothing but carborundum. The specifications state also that if desired the molded carborundum article may be made into an electrical conductor by mixing graphite with it, preferably in a proportion of 15 or 20 parts of graphite to 80 or 85 parts of carborundum. Patent No. 650,234.

◆

Live Steam Feed-Water Heaters.

To the Editor, American Electrician;

Sir:—The conclusion stated in the last paragraph of Prof. Durand's article in your May issue presenting the practical lesson drawn from his previous discussion is certainly in almost all cases false.

In a steam-power plant where the main engines are worked condensing and the auxiliaries non-condensing, the latter's exhaust heating the feed water from 100 degs., the temperature of the hot well, to 210 degs., let the total consumption of steam be denoted by 1, i.e., take this quantity as the unit measure of steam; let

$a =$ the steam consumption of the auxiliaries.

If now these same auxiliaries be made condensing, let

$c =$ the amount of live steam taken from the boiler to heat the feed water from 100 degs. to 210 degs.;

$d =$ the additional amount of steam consumed by the main engines as a result of the withdrawal from their receivers of steam for heating feed water from 100 degs. to 210 degs.;

$f =$ a factor depending upon the type of the main engines and expressing the ratio which the work performed in their final cylinders bears to their total work.

The steam consumption of the auxiliaries condensing will not be less than 0.8 of their consumption non-condensing. The total steam consumed under the new conditions will be

$$S = 1 - a + 0.8a + c + d = 1 - 0.2a + c + d \text{............(1).}$$

The gain or loss under the changed conditions will be found by subtracting S from unity, giving,

$$1 - S = \triangle = 0.2a - c - d\text{....(2).}$$

If $\triangle$ be positive the change is economical; if negative, it is wasteful.

The steam required to heat the feed water from 100 degs. to 210 degs. is almost exactly 0.1 of the total consumption.

Where the main engines are simple $d = 0$

$$c = 0.1\ (1 - 0.2a + c) = 0.11 - 0.02a.$$

Substituting in (2) we have

$$\triangle_s = 0.22a - 0.11\text{.........(3).}$$

$\triangle_s$ is negative for all values of a less than ½.

Where the engines are compound and the steam for heating the feed water from 100 degs. to 210 degs. is taken from the last receiver, $c = o$ and (2) becomes

$$\triangle_c = 0.2a - d\text{.............(4)}$$

(1) becomes

$$1 + d - 0.2a = S\text{..........(5).}$$

The total steam required for the heaters is then $0.1\ (1 + d - 0.2a)$.

The total work of the main engines $=$ $m\ (1 - a)$ where m is an unknown constant.

The withdrawal of the steam for the heaters reduces this work to $m\ [1 - a - 0.1\ f\ (1 + d - 0.2a)]$.

To produce the original amount of work will then be required of steam

$$\frac{(1-a)}{[\,1 - a - o.1f\ (1 + d - 0.2a)\,]}\ (1 - a)$$

$$d = \frac{(1-a)^2}{(1-a) - 0.1f\ (1 + d - 0.2a)} - (1 - a)\text{..(6).}$$

By (4) we know that if $0.2a = d, \triangle_c = o$. That value of a which makes $0.2a = d$ marks the dividing line between those conditions where the proposed change will be economical and those where it will be wasteful. When a is less than 5d, the change to condensing auxiliaries is wasteful; when a is greater than 5d, it is economical.

Substituting in (6) $d = 0.2a$ we have

$$\frac{(1-a)^2}{(1-a) - 0.1f\ (1 + 0.2a - 0.2a)} - (1 - a) = 0.2a\text{...(7).}$$

$$a = \frac{1 + 0.4f}{2} \pm \sqrt{\left(\frac{1 + 0.4f}{2}\right)^2 - 0\ 5f}\text{.(8).}$$

For a two-cylinder compound $f = ½$ approximately. Substituting in (8) we find

$$a = 0.27 \text{ or } 0.93\text{..........(10).}$$

For a three-cylinder compound $f = 1/3$ approximately

$$a = 0.16 \text{ or } 0.93.$$

We find then that a change from non-condensing auxiliaries whose exhaust heats the feed water from 100 degs. to 210 degs., to condensing auxiliaries, live steam or steam from the last receiver of compound engines being used to heat the feed water through the same range, will be wasteful unless with the different classes of main engines the total steam consumption of the auxiliaries exceeds the following amounts:

For simple engines, 50 per cent of the whole.

For two-cylinder compound, 27 per cent of the whole.

For three-cylinder compound, 16 per cent.

The live steam heater and heaters drawing from the compound engine receivers have their uses, but among them is not, commonly, to replace the heating of the feed water from 100 degs. to 210 degs. by the exhaust from the auxiliaries.

John Wilson Brown, Jr.

Philadelphia, Pa.

The point raised by Mr. Brown turns chiefly on the meaning attached to the term "exhaust heater," and on the extent to which such a heater connected with the auxiliary exhaust can be used to raise the temperature of the total feed for an entire plant. By exhaust heater I have implied a heater in which the exhaust steam and the feed are not mixed, and through which the exhaust passes, becoming cooled and partially condensed, the remainder of the exhaust escaping as steam with whatever total heat it may possess, as determined by its temperature or pressure.

Now, to raise the temperature of the total feed 110 degs., or from 100 degs. to 210 degs. by means of the heat drawn from the auxiliary exhaust, would require the condensation of an amount of steam equal to 10 or 11 per cent of auxiliary steam, and the total condensation of this auxiliary exhaust would just about suffice to raise the temperature of the total feed by the above amount. This is readily seen when we note that we must expect somewhat less than 1000 heat units per pound of exhaust, taking into account its usual "wet" quality and its temperature of escape to the air. There is the further point to be borne in mind, that all steam thus escaping to the air must be made up in feed water from the source of supply, at a temperature of perhaps 60 degs., thus requiring an additional supply of heat.

The conditions thus assumed by Mr. Brown would therefore imply for a plant as above assumed and using such a heater, the complete condensation of the auxiliary steam. This is a condition quite different from that which usually exists with such heaters.

The matter therefore turns on the question regarding the auxiliaries, whether it is better to operate them condensing, thus saving all their steam and turning it into the feed-water, or to operate them non-condensing, losing this part of the feed, but saving a part of the heat by means of the main feed water. The result will turn on the proportion of auxiliary to total steam, and on the extent to which the auxiliary steam is condensed in the heater; and in the cases which have come under my observation, more especially for multiple-expansion engines, which were indeed chiefly held in view of the article referred to, the results would indicate an anvantage for the first mode of operation.

If, on the other hand, the auxiliary steam is led to a "condensing heater," or "heating condenser," whichever it may be termed, so that it is all condensed and not rejected, then the case will be different, and the operation of the auxiliaries in this manner is in general likely to be conducive to an increase in economy.

It is not necessary to consider in detail the algebraic analysis which Mr. Brown gives, since it relates to a set of conditions different from those which I have assumed, and I am sure that we shall be quite agreed that the whole secret of economy lies in this—having given a certain amount of heat, to prevent its escape or disappearance otherwise than as mechanical work—and that the mode of operation which secures the minimum loss or escape of heat as such, will give the highest economy. In fact, the complete condensation of the auxiliary exhaust and its use in a condensing heater is an example of a transfer of heat from the exhaust stage to the heating stage especially referred to in my original article as furnishing a transfer of heat usually favorable to an increase of thermodynamic efficiency.

W. F. Durand.

Cornell University,
Ithaca, N. Y.

Hot Wire Shunted Ammeters.

To the Editor, American Electrician;

Sir:—In reply to Mr. W. J. Lloyd's letter in your July number criticising my article on the "Use of Hot Wire Shunt Instruments as Alternating Ammeters," which appeared in the April number, I would say that my observations were arrived at from practical cases, and that the suppositious case mentioned is one not infrequent in practice. I have found in several cases where hot wire instruments had been calibrated with direct current that the indication of the instrument varied 10 per cent and over, although as a rule the error was less than that.

No doubt, under some conditions the direct-current and alternating-current calibrations of a hot-wire instrument used with a shunt would check up very closely; but it was the intention of my article to point out that it was possible to obtain errors on a hot-wire instrument with the alternating current when the direct-current calibration is correct, and that these errors may be easily obtained in practice if in the installation of the apparatus the proper constants (resistance and reactance) of the circuit are not obtained.

E. A. Wagner.

Schenectady, N. Y.

G. E. and T-R. Generators in Multiple at the Windber Mines.

To the Editor, American Electrician;

Sir:—In my article on "Electric Haulage at the Eureka Mines," which appeared in your July issue, the statement near the bottom of the first column on page 318, that "The resistance of the series coils of this machine being much greater than that of the series circuit of the General Electric generators, part of the T-R. coils were left outside the equalizer circuit, only as much as were required to equal the resistance of the series circuits of the G. E. dynamos being included between the equalizer connection and the brush," is erroneous, as Fig. 7 indicates. The latter part of the statement should have read: "Only as much as were required to equal the resistance of the series circuit of a G. E. dynamo being included between the equalizer tap and the positive bus-bar."

It may be as well to point out also some errors in the diagram, Fig. 8. This diagram shows both of the wires leading from mine No. 30 over to the other mines connected to the negative bus-bar, whereas the left-hand wire should have been connected with the positive bus-bar, of course. It also shows the positive and equalizer leads of the T-R. dynamo transposed. These errors, which were evidently due to the engraver, will be obvious, of course, to any engineer who is accustomed to laying out circuits, but as they may be somewhat misleading to students and beginners I deem it best to point them out.

A. S. McAllister.

Windber, Pa.

NEW BOOKS.

The Electromagnet. By Townsend Wolcott. Part II., by Richard Varley. Jersey City, N. J.: The Varley Duplex Magnet Company. Leather; 58 pages, 4½x6½ inches; 13 illustrations. Price, $1.00.

An explanation of the principles of electro-magnetism written in simple and straightforward phraseology. The electromagnetic units and their application are clearly explained and formulas relating to the design of magnets are given. Instructions for the calculation of magnet windings are supplied and there is a section on self-induction which is the one and only lucid explanation the reviewer has ever seen in print. Part II comprises formulas for computing magnet windings, tables of winding constants and one of the properties of copper wire, the latter having been copied from the American Institute table without correcting the numerous inaccuracies contained therein.

Horseless Vehicles, Automobiles and Motor Cycles. By Gardner D. Hiscox. New York: Norman W. Henley & Co. Cloth; 6x9 ins.; 459 pages, 316 illustrations. Price, $3.

A comprehensive compilation containing descriptions of the various types of motor-driven vehicles, from bicycles up to omnibuses, together with descriptions of many of the gasolene engines used in this class of work. The descriptive matter is necessarily very general in character, space limitations prohibiting complete details, but many interesting details are presented. The essential information relating to the various types of vehicles is fairly complete in the text.

Gas Engine Construction. By H. A. V. Parsell, Jr., and Arthur J. Weed. New York: Norman W. Henley & Co. Cloth; 6x9 ins.; 296 pages; 140 illustrations. Price, $2.50.

The name of this book is rather misleading, as the authors do not deal with the general construction of gas engines except in a single chapter containing a few elementary rules applying to engine design. Chapters I and II relate to the principles and operation of different types of engines. Chapters III. to XXIII., inclusive, are devoted to the details of a design for a 2½x4-in. gas engine and a small carburettor for use with gasolene. Chapter XXIV is the one referred to above, and chapter XXV is an unsatisfying list of publications relating to gas and oil engines. The publishers and prices of all books, except those of Messrs. Henley & Co., are carefully omitted from the list. The chapters describing the design of a small gas engine are lucid and well illustrated. The engine is a horizontal one, designed, presumably, to run at 450 r.p.m. and develop 0.4 horse-power.

NOTES.

Attendance at the Exposition.—From the opening of the Paris Exposition on April 15th up to June 5th there nave been recorded over eight million admissions, and at the present rate of attendance it is estimated that the total number of visitors will approximate fifty millions before the Exposition closes.

Why a Barometer? — An English contemporary, mentioning the marriage of a Mr. Thursfield, electrical engineer to the Chester Corporation, states that "the employees of the station presented Mr. Thursfield with a barometer." It is not stated whether Mr. Thursfield had manifested any particular passion for a barometer or whether his duties were omnigeous to the extent of including weather forecasting, so that the particular motive in selecting a barometer as his present is shrouded in obscurity.

Valuable Information.—A daily newspaper in a recent issue was guilty of the following:

"What is electricity made of?—Subscriber.

"A.—Electricity is a potential force generated by motors, in which friction is the basic principle. Works on physics or an encyclopedia will furnish you with an unlimited amount of information on the subject of electricity, of which space forbids the reproduction here."

If the foregoing answer is an extract from any "work on physics or an encyclopedia," the remainder of that book must be entertaining literature.

Results of an Automobile Hill-Climbing Trial.—Among the contests included in the recent 1000-mile tour of the Automobile Club of Great Britain were hill-climbing trials. At one of these tests up Bunny Hill, near Nottingham, the following results were recorded: First place, the Locomobile, built by the Locomobile Company of America; second place, a 6-h.p. Panhard; third place, 5-h.p. Marshall; fifth place, 8.-h.p. Lanchester explosion motor. Twenty-one of the vehicles which made practically even records were given fourth place. Two vehicles had to tack up the hill, 12 had to discard passengers in order to get up, and 8 of them stuck; 48 vehicles competed in all.

A Substitute for Hard Rubber.—An acceptable substitute for gutta percha is reported to have been invented by a Strasburg engineer. Under ordinary temperatures the mass is said to be hard like pitch and at the same time not brittle. Thin plates were said to have been subjected to the action of sea water with good results.

A Mere Matter of Phraseology.—In a description of an English two-phase isolated power plant "The Electrical Review" (London), says:

"The low pressure carried makes it free from danger, and the alternators respond quickly (*sic*) to sudden changes of load which occur during the stopping and starting of the motors."

The same difficulty manifests itself in this country, especially where large motors are used; but it isn't described as gracefully.

Wireless Telegraphy in Hawaii.—A plan is on foot whereby the Marconi system of wireless telegraphy is to be established for the purpose of providing communication between the several islands of the Hawaiian group. The preliminary engineering work is now in progress. The privilege of sending the first message when the installation is complete will be sold at auction to the highest bidder and the price paid will be donated to some charity or benevolent institution, to be selected by the successful bidder. An offer has already been made for this privilege of $500.

Automobile Races in Belgium.—A series of automobile races was held recently at Antwerp for several classes of machines. The records made by the winners were as follows: 6-h.p. motor cycle, one mile in 1 minute and 6 3/5 seconds; light vehicles weighing 5500 lbs. and under, 1 minute and 57 3/5 seconds; light vehicles weighing 8800 lbs., 1 minute and 29 2/5 seconds; automobiles weighing under 8800 lbs., 1 minute and 25½ seconds (8-h.p. motor on the winning vehicle); automobiles weighing over 8800 lbs., 1 minute and 15 2/5 seconds (12-h.p. motor on the winning vehicle).

A Commendable Policy.—The Camden & Suburban Railway Company, Camden, N. J., has presented its employees with a recreation and reading room in its new car house, which is completely equipped with tables, chairs, a blackboard and other accessories, and has subscribed to a number of popular magazines and technical journals to be kept on file in the room. One night will be set aside in each month for the discussion of some subject in connection with the operation of the road, and a committee will be selected from among the men on each of these occasions to make investigations, tests, etc., and report on them at the following meeting, the report to be made the subject of a general discussion. The full proceedings of each meeting will be taken stenographically and kept on file.

Alcohol Motors for Automobiles.—Some of the large builders in Germany have recently tried alcohol motors for automobile delivery wagons with considerable success, and Emperor William has decided to have two of these vehicles built for the transportation of provisions and ammunition for the army. In view of the fact that for equal calorific values alcohol costs about twenty times as much as gasolene, these experiments seem rather optimistic.

Draw-Bar Pull of Electric Cars.—Tests made on the South London Electric Railway are said to have shown a draw-bar pull of 40 lbs. per ton of train at the moment of starting, which dropped to 10 lbs. per ton at a speed of six miles an hour; above six miles and up to 13 miles an hour the tractive resistance remained constant, and beyond 13 miles an hour increased almost proportionately to the speed up to a rate of 26 miles an hour, at which point the draw-bar pull was 21 lbs. per ton.

Women Automobilists Licensed.—The Chicago authorities have granted licenses for operating automobiles to six women thus far, the first successful applicant being Miss Julia Bracken, the sculptress. A significant feature in this connection is the fact that no licenses have been allowed to women for either steam or gasoline vehicles, the authorities considering only electric vehicles to be safe in the hands of the fair sex. This is obviously a strong testimonial to the reliability and ease of control of electrically-driven vehicles.

Electrical Distribution in Cotton Mills.—The Dominion Cotton Mills Company, Hochelaga, Quebec, has decided to displace its steam plant with an electrical equipment and the capital of the company is to be increased by $1,000,000 to cover the cost of this change and other improvements. An idea as to the amount of power involved may be gained from the fact that the company burns under its boilers an average of 10,000 tons of coal a year. A contract recently consummated between the Dominion Mills and Chambly Power Company provides for the delivery to the mills of 3000 electric horse-power.

Traveling Stairways for Elevated Railway Stations.—The Manhattan Railway Company has arranged to install on trial two types of traveling stairways; one form consists of an endless rubber band carrying wooden slats on which the passenger stands. The band runs over a pair of drums, one at the top and one at the bottom of the incline, and a hand rail beside it moves at the same rate; the proposed rate of travel is 90 ft. per minute. In the other type of elevator a series of electrical steps are to be used in place of ordinary wooden slats, so that the passenger stands on a level surface instead of on an incline. Each of these stairways requires a four-h.p. electric motor to drive it. There will be no traveling stairway for the descent, the ordinary steps being used for that purpose.

Tesla and the Electric Propulsion of Ships.—In a recent number of the "Century Maganzine" an article by Mr. Nikola Tesla was printed, in which some statements were made that drew caustic comment from our contemporary, "Marine Engineering." In the July number of the latter magazine the editor refers to the article as the "handiwork of a cerebrose individual * * * a bombastical genius who has illumined unknown fields of imaginative science with his intellectual searchlight and is willing to permit the gaping world of ignorance or complaisance to peep in and wonder, the credulous editor drawing the curtain. This dazzling contribution to modern unscientific research," he continues, "reads like nothing so much as an essay on Christian Science, so profound is it in the ambiguous nothingness whereby it leads through the intricacies of incoherency into the climax of absolute asininity." The particular statements made by Mr. Tesla which most aroused the editor of "Marine Engineering" were:

"Steamers and trains are still being propelled by direct application of steam power to shafts and axles. A much greater percentage of the heat energy of the fuel could be transformed in motive energy by using in place of the adopted marine engines and locomotives, dynamos driven by specially-designed high-pressure steam engines or gas engines, and by utilizing the electricity generated for the propulsion. A gain of from 50 to 100 per cent in the effective energy derived from the coal could be secured in this manner. In ocean steamers such an improvement would be particularly desirable as it would do away with noise and increase materially the speed and carrying capacity of the liners."

In the same issue of "Marine Engineering" also appears an article by Prof. W. F. Durand commenting upon Mr. Tesla's reckless statement. Mr. Durand argues, and of course soundly, that any especially efficient prime mover which can be used to drive an electric generator can also be used to drive a propeller direct so that interposing a generator and motor between the prime mover and the propeller shaft would be a gratuitous waste of energy. Mr. Durand further points out that the addition of an electrical equipment in the case of a liner having 25,000 horse-power of driving machinery would result in a loss of about one-third of the freight-carrying capacity of the ship, besides the loss of about 2500 horse-power due to the two transformations of energy, entailing a reduction in speed from half to three-quarters of a knot. "The increase of carrying capacity referred to at the close of the quotation," says Mr. Durand, "would be, therefore, of a character not likely to commend itself to the stockholders or board of directors."

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Induction Motors in Factory Service.

On another page will be found an interesting account of an application of induction motors on the largest scale thus far attempted in an isolated plant. The article referred to presents, in addition to the usual descriptive matter, some very unusual and highly interesting data, namely, a record of the starting current taken by 50-h.p. and 75-h.p. motors—which current may be considered startling as well as starting. One 50-h.p. motor took 210 amperes per leg and pulled the circuit e.m.f. from 600 volts down to 550 volts in starting up its line shaft with the individual belts from main to counter-shafts running on loose pulleys; another, driving more shafting, took 230 amperes with a voltage drop of 70, and a 75-h.p. motor took 300 amperes per leg, pulling the e.m.f. down to 525 volts. Assuming an efficiency of 90 per cent and a power factor of the same value, the full-load current per leg for these two sizes of motors is practically 44¼ and 66½ amperes, respectively. The 50-h.p. machines took, therefore, overloads of about 400 per cent (five times normal full-load current), and the 75-h.p. motor stood an overload of about 350 per cent (four and a half times the normal full-load current).

These figures naturally impress a direct-current engineer as being frightfully and unreasonably trying. Moreover, exclusively direct-current advocates will be prone to argue that such enormous starting currents constitute a serious bar to the use of induction motors for such work. This argument would be entirely valid if applied to conditions demanding the frequent starting and stopping of motors taking these abnormal starting currents. As a matter of fact, however, the very conditions which impose excessive starting currents, in the case under consideration, also involve starting up only twice a day—in the morning and after the mid-day dinner hour. Furthermore, the overload period is so short that the volume of the starting current is almost a matter of indifference so far as damage to the motors and generators is concerned. As to the energy, it must be borne in mind that the power factor at starting is extremely low, so that the volt-amperes passed are several times as great as the true watts.

However, there is no gainsaying the fact that the heavy starting currents above noted are decidedly disadvantageous. If the results of these tests may be taken as representative, they indicate plainly that induction motors as now built are not efficiently applicable where an appreciable load must be started from rest at frequent intervals during the working day by a direct-connected motor. Where the motor can run continuously and the load is either continuous or thrown on and off by means of a clutch or its equivalent, induction motors are all that can be expected. Under such conditions the ease of maintenance and negligible degree of attention required will almost always compensate for the low power factor and efficiency which characterize induction motors as compared with direct-current machines.

◆

Street Lighting.

It has long been recognized in a vague sort of way that incandescent lamps located at sufficiently short intervals to secure actual illumination midway between them give far better effect than arc lamps of the same aggregate mean spherical candle-power distributed over the same area. But the cost of maintenance per candle-power is so largely in favor of arc lamps that the matter has been persistently dismissed with the explanation that adequate illumination by means of the smaller light units was an uncommercial ideal. The advent and cordial reception of the enclosed arc lamp, however, resulted in the serious investigation of the question of street illumination, as differentiated from the indiscriminate production of bright light in large units, which is now in active progress. Empiricists who have declined to admit that judicious distribution is preferable to concentrated brilliance are being gradually but inexorably driven to face one of two alternatives—reason or ruin. No sane man will hesitate in choosing between these alternatives when convinced that the choice is inevitable; the difficulty lies in establishing this conviction before it is too late to make a choice. Undecided central station men who have a weakness for old methods will find it profitable to read thoroughly the articles on street lighting which have been printed in recent issues of this paper and the culminating discussion which appears on another page of the present number.

The curves prepared by Mr. Wait show that with 450-watt arc lamps located 300 feet apart and 25 feet above the ground, the minimum illumination midway between lamps is practically the same for all three types—direct-current open, direct-current enclosed and alternating current enclosed arcs. The only appreciable difference is near the lamp, where the light from the open arc is much stronger, of course, than that from either of the other two, the alternating arc being the weakest. The mean hemispherical candle-powers of the arcs were 566 for the open arc, 424 for the direct-current enclosed arc and 288 for the alternating-enclosed arc, which goes to show the fallacy of comparing sources of light for street service by measurements taken at or near the source.

The comparison of incandescent lamps with the three types of arc lamp is also highly instructive. It shows not only that with equal mean spherical candle-power per linear foot of street-incandescents give better effective illumination than arcs, but that they do so with equal expenditure of energy per linear foot of street. The comparison is made on the basis of 3-watt lamps in clusters 150 feet apart and 15 feet above ground, under reflectors which render available one-third of the light rays which would be sent into the upper hemisphere without reflectors; these assumptions are certainly not radical. The minimum surface illumination midway between the clusters is practically the same as in the case of the arc lamps, but as the points of maximum illumination are one-half the distance apart with incandescents the effect on a street would be somewhat better than with arc lamps. The power consumption per linear foot of street is the same in all four cases.

Starting Up Motor-Driven Factories.

One of the objections frequently urged against direct-current motors for use in large factories where each motor drives a line of shafting is that the motors must be started up individually after the generating plant is under way. This is at best (or worst) a lazy man's excuse, as the time and effort required for starting up a motor are ridiculously small. Nevertheless, the protest is made seriously, and it is usually accompanied by another objection of more weight, to the effect that motor-starting boxes are more or less incendiary in character and "are always giving trouble." Leaving aside the intrinsic merit of this argument, it is a very simple matter to eliminate the bugbear of starting up line-shaft motors individually in the ordinary manner and to reduce the motor-controlling equipment to three switches, or two switches and a circuit-breaker, which can be housed in a cast-iron box if necessary for the protection of inflammable surroundings.

In addition to the two usual wires a teaser wire of comparatively small cross-section could be run, to which one terminal of the field-magnet winding of every motor would be connected; the other field terminal would be connected to one of the mains, independently of the armature circuit, a small double-pole knife switch controlling the field connections. The armature circuit of the motor would be connected to the two mains through either a double-pole switch or a circuit-breaker—preferably the latter. In the generator room there would be an exciter dynamo capable of supplying the fields of all the motors and of the main generator or generators, the teaser wire above mentioned serving as one side of the exciter circuit and one of the mains on the other side.

At starting time, the exciter dynamo would be started first and all of the fields fully excited, including those of the main generator; the main circuit would be closed before starting up the generator, and upon starting this machine all of the motors would also start, picking up in speed as the e.m.f. of the generator picked up. This would give precisely the starting condition as that obtained in a purely shaft-and-belt plant, and eliminate the individual starting of the line-shaft motors. This method was suggested by the experiment made at the Deering works of starting up induction motors from the generator room, as described in another column.

For emergencies, such as trouble with a motor or a section of shafting, means must be provided for stopping and starting the motors separately. The switches previously referred to furnish means, of course, for stopping; for starting, the motor could be provided with a powerful series field winding, of comparatively small wire so as to introduce as much resistance as would be safe, and a single-pole knife switch to short-circuit this winding when the motor is well under way. With this switch open and the shunt field fully excited as above described, the armature and series field could be thrown directly on the main circuit, and the starting current need not be dangerously heavy. There would be the drawback of subjecting the armature to a high torque at standstill, but with a properly designed and constructed machine this would not entail or even threaten disaster. We have seen 10 and 15-h.p. motors started in this way, day in and day out, without the slightest damage. As this individual starting would be called into service only at infrequent intervals the heavy rush of standstill current would not be a serious consideration. Of course, where individual motors are employed the plan here outlined is both impractical and superfluous.

Storage Batteries for Small Stations.

It has been long recognized by most engineers that reckless advocacy of any engineering system or type of apparatus will do more harm to that system or type than any amount of unjustified denunciation that can be heaped upon it. The reason is, of course, that heedless enthusiasm causes apparatus to be installed in many places for which it is either totally unfitted or in which it is not efficient, resulting ultimately in the throwing out of the apparatus and the spreading abroad of exaggerated statements concerning its short-comings. The history of all branches of electrical industry abounds in instances of this kind, particularly that of storage batteries, the advancement of which has been conspicuously retarded by over-sanguine attempts to exploit them regardless of expediency. There still remain many battery advocates (aside from the manufacturers, whose partisanship is entirely natural) who are always anxious to recommend the installation of a battery auxiliary as a sort of panacea; any opportunity for an accumulator equipment is welcomed as eagerly as a Donnybrook Irishman is proverbially supposed to welcome the sight of an unhit cranium.

On the other hand, there is the saving conservative element, to whose discriminating judgment most of the signal successes of storage batteries have been due; in this class evidently is the author of the paper read before the recent Northwestern convention at Waupaca. In this paper was specified the definite limit of 1½ hours as the maximum duration of load peak that justifies the installation of a storage battery auxiliary under normal central station conditions. This may seem a trifle arbitrary and there are doubtless many stations in which the rule would not hold good. Where a large proportion of the total load consists of motors a battery would obviously be advantageous and might be necessary in smoothing out the voltage fluctuations, regardless of the duration of the load peak. But there are very few small stations carrying a heavy motor load at night or a heavy lamp load in the daytime, one of which conditions is necessary to justify the use of a battery for maintaining even voltage. Mr. Ferguson's rule was evidently intended to apply only to the question of employing a storage battery to take care of the peak of the load, without reference to other problems of which the storage battery might afford really the only commercial solution.

THE CONSTRUCTION OF A REACTIVE COIL.

It is well known, of course, that reactive or "choking" coils are used in alternating-current work instead of ordinary resistance coils for the purpose of reducing the e.m.f. in a portion of a circuit because they are much less wasteful than resistance coils or rheostats. As the uses of reactive coils are so diverse no one design can be given which will fit all cases; hence only one form will be described here in detail, and rules will be given by means of which anyone can modify the design to fit any case.

The reactive coil here described is designed for use in series with one, two or three open arcs on a constant-potential circuit of 100 or 110 volts, or with one lamp on a 50-55 volt circuit, or with three enclosed arc lamps fed from a 200-volt circuit. Its dimensions and windings are based upon a magnetic density of 30,000 lines of force per square inch in the core and it may be adjusted to pass any current from ½ ampere to 15 amperes. The apparatus is of the adjustable core type, and if desired, the winding can be tapped at various points and the coil can be used as an auto-transformer.

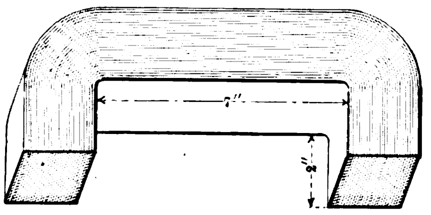

FIG. 1.—THE CORE.

The core consists of rectangular plates of No. 27 transformer iron, 14 ins. long and 2 ins. wide, bent into the form shown by Fig. 1. The thickness of the core must be 2 ins. The easiest way to assemble it is to make an iron template like Fig. 2, of ½-inch strap iron and bend the successive plates of the core into shape over the template, one at a time, leaving them in position as they are bent. Clamp the strips to the template as shown in Fig. 3 and bend the ends down without resorting to any hammering whatever. The core must measure 2 ins. in thickness when clamped tightly. As each strip is bent down into shape its ends should be squared off with a pair of tinners' snips, so that when all are bent the ends will all be flush, forming a laminated pole-face at each end of the core, as indicated in Fig. 1.

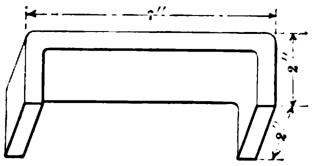

FIG. 2.—TEMPLATE.

When the last strip is in place, remove the template, replace the clamps near the corners of the core and bind the core strips tightly together with heavy cord (at least 1/16 in. in diameter), winding a full layer from bend to bend, and pulling each turn just as tight as the cord will stand it. The best way is to take a couple of turns at one corner and tie the cord; then loosen the clamp and move it an inch away, setting it up tight again; wind the cord over this inch of space and move the clamp another inch, continuing this procedure until the whole core is covered between the two bends. After binding the core with cord in this manner, cover it with two layers of insulating tape, carrying the tape around the bend and out almost to the end of the right-angle poles. Then wind on that portion of the core between the bends 200 turns of No. 8 double cotton-covered magnet wire in four layers. When this is done secure the ends of the core between three clamping blocks mounted on a base board, as shown in Fig. 4.

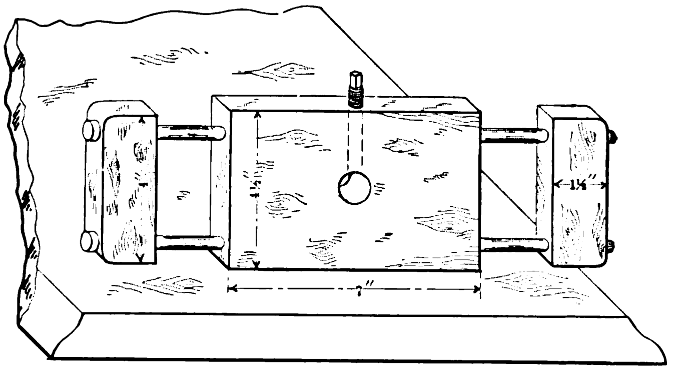

FIG. 4 —WOODEN CLAMPING BLOCKS.

The yoke which completes the magnetic circuit is somewhat similar in form to the core just described, as Fig. 5 indicates, but the right-angle projections at each end of the yoke are much shorter than those of the main core. The exact length of these projections is immaterial except that it should be not less than an inch and not more than two. The yoke will preferably be built up in the same way as above described in connection with the main core, and after it is bound together with twine it should be mounted in the clamp shown in Fig. 6 in such a way that the center of the spindle projecting from one side of the clamp will coincide with the center of the yoke structure. The clamp jaw should be made a snug fit for the yoke so that the bolts will not need to be drawn up very tightly. The bolts must be insulated from the metal of the clamp by bushings of either hard fiber or rubber in order to avoid forming a closed circuit around the yoke, which would result in a heavy flow of current through the clamp and bolts.

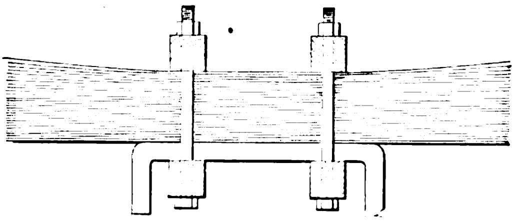

FIG. 3. CORE PLATES ON TEMPLATE

The spindle is seated in a bushed hole through the center of the long clamping block shown in Fig. 4, so that the ends of the yoke can be brought into alignment with the pole-faces of the main core. A round-nose set screw through the upper edge of the clamping block will serve to hold the spindle in any position to which it may be adjusted. Two adjustments are available, one in a rotatory direction about the center of the spindle, and the other in a straight line toward and away from the pole-faces of the main core. This latter adjustment is preferably made by means of a round nut fitted to a fine screw thread on the spindle, as indicated in Fig. 6, the set-screw in the clamping block being used merely to secure the core in any position to which it may be adjusted. To use the apparatus as a choking coil, connect the winding in series with the lamp or lamps, adjust the regulating nut on the spindle so as to secure the length of air gap specified in the accompanying table and secure finer gradations by twisting the yoke into or out of alignment with the pole-faces of the main core until the exact choking effect is secured, when the set-screw may be used to hold the yoke in that position. The length of air-gap given in the body of the tables refers to each of the two gaps, not the sum of the two.

LENGTH OF AIR GAP; OPEN ARC LAMPS.

Amp.	1 Lamp; 52-volt circuit.	Lamps on 104-volt circuit.		
		1	2	3
4	9/64	1/32	1/16	1/8
6.6	1/4	1/20	1/10	7/8
7.5	17/64	1/16	7/64	15/16
10	3/8	5/64	9/64	1¼
12	7/16	3/32	3/16	1¼
14	1/2	7/64	7/32	1¼

LENGTH OF AIR GAP; ENCLOSED ARCS.

Amp.	1 Lamp; 100-volt circuit.	Lamps on 200-volt circuit.		
		1	2	3
4	5/64	1/64	1/32	1/4
6.6	1/8	1/40	1/20	7/16
7.5	9/64	1/32	3/64	1/2
10	3/16	3/64	1/16	3/4
13	1/4	1/16	3/32	1

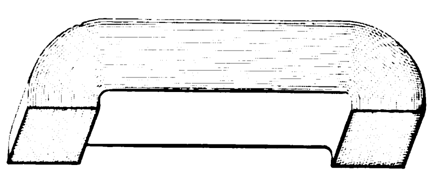

FIG. 5.—THE YOKE.

If it should be desired to use the apparatus as an auto-transformer the yoke should be brought into accurate alignment with the pole-faces, pushed up solidly against them and held in this position permanently by means of the setscrew. Used in this manner, the winding will have to be tapped. Each turn of the winding will represent 1/200 of the e.m.f. of the circuit, so that to operate a single 33-volt lamp on a 50-volt circuit one terminal of the lamp must be tapped into the winding of the autotransformer 133 turns distant from the other terminal, or preferably at 2/3 the distance from one end, as indicated in Fig. 7. Fig. 8 indicates the arrangement of the taps for three enclosed arc lamps on a 200-volt circuit. Taps would be taken out at exactly the same points to supply three open arc lamps on a 100-volt circuit.

Should the reader desire to construct a reactive coil to suit any other conditions, the following simple formulas will give the required dimensions and winding. For work on a 133-cycle circuit the choking effect in volts for a coil built for the average conditions of practice is given by the formula:

$$0.18 \times T \times A = E \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

In this formula A is the area of the core cross-section and T is the number of turns of wire. In order to make this formula hold good the number of turns of wire must agree with the formula:

$$\frac{2.6\,L}{C} = T \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

In this formula L is the length of the magnetic circuit within the iron, including the yoke, and C is the current in the winding. For 60-cycle circuits

$$0.11 \times A \times T = E \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

in which the number of turns must agree with the formula:

$$\frac{3.5\,L}{C} = T \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

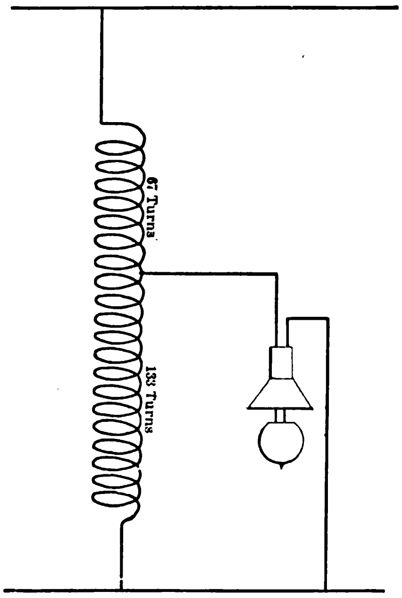

FIG. 7.—CONNECTIONS AS AUTO-TRANSFORMER; ONE LAMP.

It should be borne in mind that the two joints between the yoke and the main core when they are in actual contact are equivalent to about 50 ins. of iron, so that in figuring the closed circuit 50 must be added to the actual length of the magnetic circuit in the iron.

The size of the wire to be used on a coil may be ascertained by allowing 1000 circular mils of cross section per ampere of current. In designing a reactive coil the dimensions for maximum output should be calculated, first assuming the yoke in contact with the main core, because anything below the maximum effect can be obtained by adjusting the distance between the yoke and the main core.

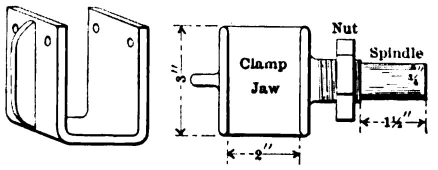

FIG. 6.—CLAMP FOR YOKE.

As an example, suppose it were desired to build a coil to regulate the impressed e.m.f. of a circuit of 6.6-ampere lamps fed from a 200-volt transformer, the range of regulation or choking effect being from 25 volts to 150. Transposing formula (1) into:

$$\frac{E}{0.18 \times T} = A$$

and assuming temporarily 100 as the number of turns, the area of the core will be, for the maximum reactive effect of 150 volts, a little over 8 ins. Making the core 3 x 3 ins. will give an area of 9 sq. ins., which will allow the number of turns to be reduced to

$$\frac{150}{0.18 \times 9} = 93 \text{ (practically).}$$

Now transposing formula (2) to read:

$$\frac{C \times T}{2.6} = L$$

and substituting for C and T the values of 6.6 and 93 respectively, we find that the length of the magnetic circuit (if it were all iron) would need to be 2361 ins., which, of course, would be a ridiculous dimension. It must be remembered, however, that any air-gap is equal to practically 2500 times its length of iron; therefore it is only necessary to make the iron core long enough to accommodate the winding and then insert an air-gap of such a length as to bring the total reluctance equal to that of 2361 ins. of iron.

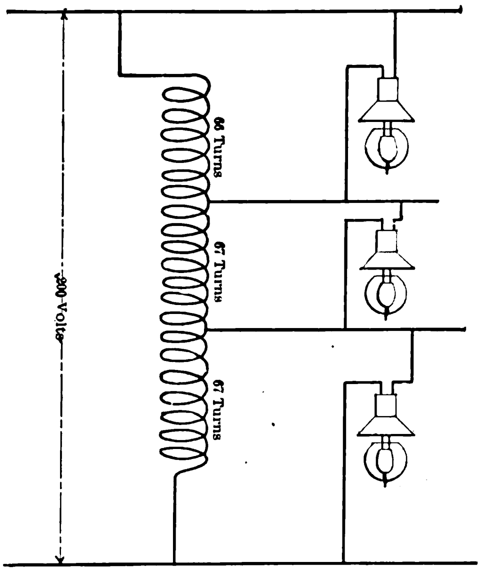

FIG. 8.—THREE ENCLOSED ARCS ON 200-VOLT CIRCUIT.

No. 12 wire will be large enough to carry the current, and the diameter of this over the insulation is 0.092 in.; 93 turns side by side, therefore, would make a coil 8½ ins. long, which would be unnecessarily long. Winding the coil in two layers the length is reduced to 4¼ ins. The total length of the iron part of the magnetic circuit may be made about 20 ins., so that the two air-gaps must be made equivalent to 2361 — 20 = 2341 ins. of iron. As each inch of air-gap is equal to 2500 ins. of iron, the total length of air-gap required will be:

$$\frac{2341}{2500} = 0.9364 \text{ in.,}$$

so that each air gap will be practically 15/32 of an inch long in order to bring the choking effect of the coil down to 150 volts with 6.6 amperes flowing through the winding.

The foregoing formulas and instructions are based on a magnetic density of 30,000 lines per square inch in the core of a coil to operate on a 133-cycle circuit, and 42,000 lines per square inch in the core of a coil to work on a 60-cycle circuit. While the density can be carried much higher than this and the size of the core correspondingly decreased, more satisfactory results will usually be obtained by employing the densities here given, because with higher densities the hysteresis loss in the core will cause it to overheat and jeopardize the coil.

INTERIOR TELEPHONE SYSTEMS.

BY W. S. HENRY.

INTERCOMMUNICATING SYSTEMS.

An intercommunicating system may be defined as a system having three or more telephones connected to the same system of wiring in such a manner that one may from any station call up and converse with any other station without requiring any central-station switchboard whatever. Intercommunicating systems require one wire from each station to every other station and at least one more wire running through all the stations. Where vibrating bells and one common ringing battery are employed, at least two more wires than there are stations are necessary. At each station there must be a switch of some kind whereby the telephone at each station may be connected to any one of the wires belonging to the other stations. Intercommunicating systems are very practical and satisfactory up to fifteen or even twenty stations; beyond that the large number of wires running through all stations makes the cost of the system increase rapidly, especially when the stations are some distance apart. For a large number of stations well scattered a simple central-station switchboard system would be preferable.

Fig. 18 shows a very common but not a good method of interconnecting a number of telephones, where each station is equipped with ordinary series bells and magneto-generators. Theoretically, any number of telephones may be connected on such a system, but practical considerations would place the limit at about twenty. In this figure there are four stations; at Nos. 1, 2 and 4 the telephone connections are drawn in full, while at No. 3 is shown the telephone outfit as it usually appears. There are four individual line wires, numbered 1, 2, 3 and 4, and a common return wire. Thus there is one more wire than there are stations and all these wires run through all the stations, each wire being tapped at each station and not cut. At each station there is one ordinary telephone instrument consisting of the usual talking apparatus, magneto-generators and polarized bells. Below each telephone there is an intercommunicating switch, of the "strap" variety. It is usually mounted upon the backboard of the telephone instrument, when the latter is made especially for this purpose. One terminal, b, of each telephone is connected to the lever, L, of the strap-switch and the other terminal of each telephone is connected to the common return wire. The lever, L, is arranged to slide over and make contact with any one of the buttons numbered 1, 2, 3 and 4. These buttons at each station are connected to the line wires bearing the same numbers. It will be noticed that the first left-hand button at each station bears the same number as the station to which it belongs; thus, at Station No. 1, the first button on the left is 1, at Station No. 2 the first button on the left is 2, and so on. This first left-hand button at each station is called the home button and the lever when resting on it is said to be in the home or normal position.

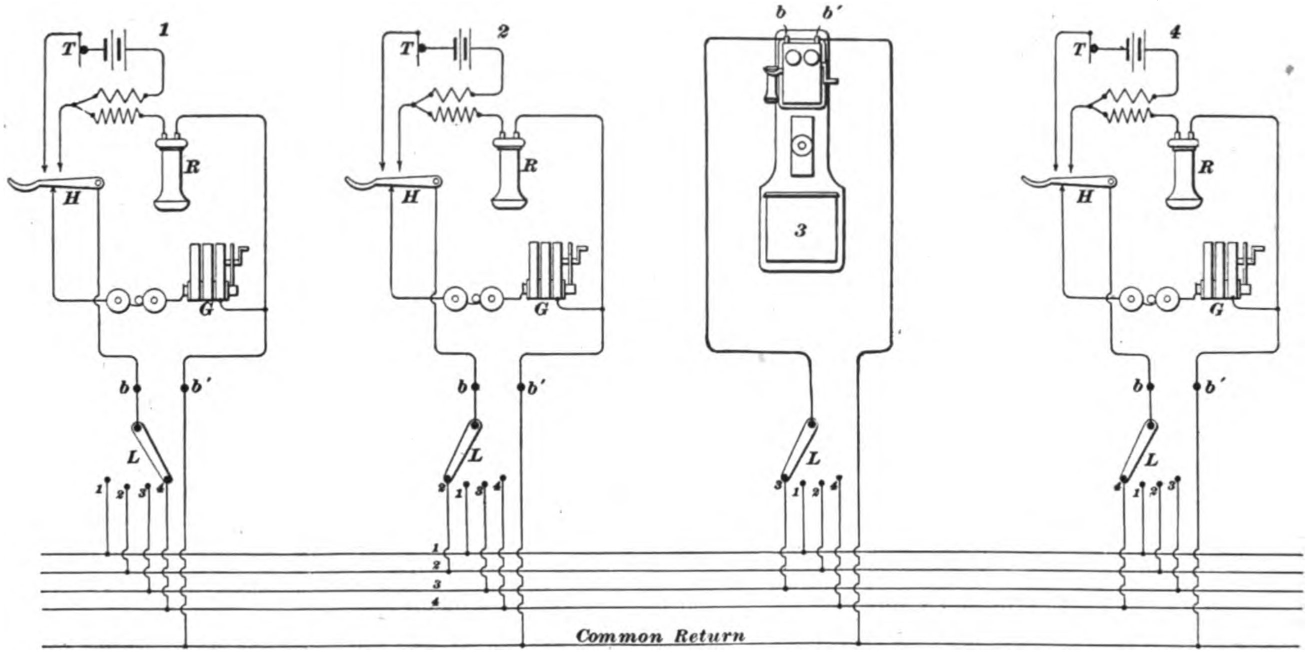

FIG. 18.—ORDINARY INTERCOMMUNICATING SYSTEM, WITH MAGNETO SIGNALLING GENERATORS AND POLARIZED BELLS.

When the telephones are not in use the switch levers should always rest on the home buttons. With all the levers in this position a person at any station can call up any other station by moving the switch lever to the button connected with the individual line of the station desired, and turning the generator handle; only the bells at the home station and at the station called up will ring. The ringing and talking currents pass through only the instruments at the stations in communication. After finishing the conversation, the switch lever at the home station must be returned to its home position, otherwise the system will be crippled. For example, the illustration shows the switch lever at Station 1 in position for calling up and talking with Station 4. If the lever is left in this position, Station 1 cannot be called up by any station except No. 4; and furthermore, if any other station should call up No. 4 the bell at No. 1 will also ring, because that station is connected in parallel with Station 4. This is a serious defect of the system, because careless or ignorant persons will very frequently, if not invariably, fail to return the switch lever to the home position. Several arrangements have been devised for overcoming this difficulty. A recent patent (No. 639,830) describes a device which prevents the hanging of the receiver upon its hook when the intercommunicating switch lever is not in its normal position. It consists of a rather simple intercommunicating switch with an attachment that blocks the entrance to the receiver hook whenever the intercommunicating switch lever is off the home position, so that the switch lever must be returned to its home position before the receiver can be hung up. This device, including the switch, may be applied to most any telephone.

In the intercommunicating system shown by Fig. 18, just as many independent conversations may be held at the same time as there are pairs of telephones. The telephone apparatus arranged as shown at each station in Fig. 2, and at Station 3 in Fig. 8, in previous articles in the May and June numbers of the American Electrician, may be used if desirable in place of the apparatus shown at each station in this figure.

In Fig. 19 is shown a method of wiring the intercommunicating switch that avoids the principal objection mentioned in connection with Fig. 18; that is, the failure to return the switch to the home position does not leave the station so that it cannot be called up. Only four stations are shown, but the system can be extended to include as large a number as may be desirable. The usual telephone sets, consisting of a microphone transmitter, induction coil, receiver, hook switch, two cells of battery, a series magneto-generator and polarized bell, are included in the outfits indicated by T_1, T_2, etc. The inside connections of these telephones are the same as shown in the preceding figure. The same telephone apparatus and connections could be used at each station in this figure as shown at each station in Fig. 2, and at Station 3 in Fig. 8 in the May and June articles. In Fig. 19 one binding post of each telephone is connected to the common return wire and the other binding post is connected to both the lever arm, s, and the individual line-wire belonging to that particular station.

Although this is a very simple change it renders the arrangement shown in Fig. 19 very much superior to that in Fig. 18. The home button in this last system is the first on the left and is not connected to anything; it is really a dummy button, but it should be there by all means, for the lever, s, of the switch should always be returned to it when the original calling party leaves the telephone. If all switch arms, s, are on the home buttons it will be found that the circuits of all instruments are open and no bell will ring, no matter what generator is turned. If Station 2 desires to call Station 1 it will be necessary to first move the switch arm, s, at Station 2 to button 1. The path of the current when Stations 1 and 2 are connected in this manner may be traced as follows: From telephone, T_2, to the switch lever, s, button 1; line 1; telephone T_1; and common return wire to Telephone T_2, the starting point.

Currents will flow through the instruments at these two stations only, because line 1 is open at all other stations. If the switch lever at Station 2 be left as shown instead of being returned to its home position a person at Station 1 can call up Station 2 without moving his switch to button 2, and if he does move the lever to button 2 he will still call up only No. 2. If No. 1 wishes to ring up No. 3, and moves the lever to button 3, the turning of his generator handle will ring not only his own bell but also the bells at both Stations 2 and 3, because the three stations are now in parallel with each other. If both parties reply, No. 1 can dismiss No. 2 and hold his conversation with No. 3 as originally intended.

Again, suppose that No. 2 allows his switch to remain on button 1 and that Station 4 wishes to ring up Station 3. When No. 4 puts the lever of his switch on button 3 and operates his generator, only him own bell and the bell at Station 3 will ring. However, if No. 4, desires to call either No. 1 or No. 2 and turns his switch to button 1 or button 2, he will ring the bells at both Stations 1 and 2.

Thus, while stations other than the one desired may be called if the switches are not properly returned to the home buttons, still it is always possible to call up the one desired, unless a large number of switches, including the one desired, are off the home buttons. In this latter case failure would be due to the fact that there were so many bells in parallel that the current through each bell would be too feeble to ring it. Moreover, even if the bells would ring, the talking current may be subdivided so much that the result, as far as articulation is concerned, may be unsatisfactory. In this system, as in the preceding one, all the telephones can be in use simultaneously in sets of two without any interference or cross talk.

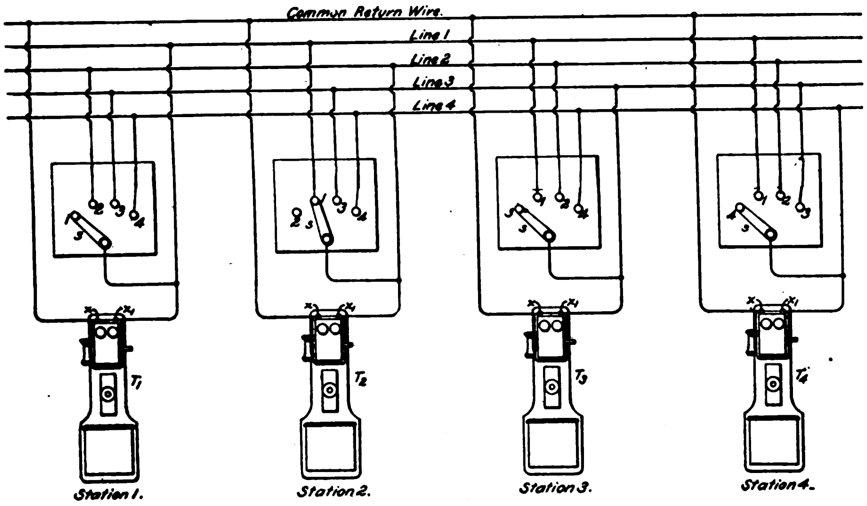

FIG. 19.

Fig. 20 is an intercommunicating telephone system similar to that shown in Fig. 19, but arranged for vibrating bells and one common calling battery, CB, in place of magneto-generators and polarized bells. A battery is used at each station for operating the transmitter. This is probably the best arrangement of batteries for such a system where vibrating bells are used. This system requires one more wire than that shown in Figs. 18 and 19, where magneto-calling apparatus is employed, thus there are two more wires throughout than there are stations. The calling battery, CB, must be connected to the two wires shown, but it may be located at any convenient place. In this arrangement only the bell at the station called will ring, the bell at the calling station remaining silent; this is not a serious objection, although it is a little disadvantageous. If the bells were not arranged in this manner, the vibrators on the two bells that happened to be connected in series when making a call might interfere more or less with good ringing. Furthermore, it would not do to short-circuit any of the vibrators because there is no telling which two stations may be connected together in making a call.

The push or lever, K, is so made that it normally rests against the upper contact. When depressed it cuts out the home bell and connects the selective switch with the battery wire. If Station No. 1 desires, for instance, to call Station No. 2, the arm of the selective switch at Station No. 1 is first turned to button 2 and the signalling button, K, is depressed. This rings the bell at Station No. 2 and the two stations may then communicate with each other after removing their receivers from the hooks.

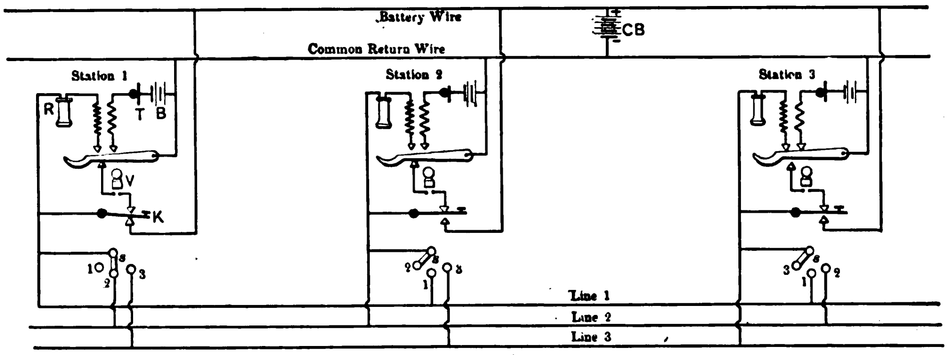

FIG. 20.—COMMON SIGNALLING-BATTERY SYSTEM.

While it is desirable to always return the switch to the home button after finishing a conversation, still it is not absolutely necessary, for no matter upon what button the lever is left, the telephone can never be cut out so that it cannot be called up again. All the telephones may be in use in sets of two at the same time, each pair so connected being independent of all others. If a third station connects with either one of two other stations that are already in communication, then all three stations are connected in parallel, and the secrecy and strength of tone are modified.

If the switch at Station No. 1, for instance, is left on button 2 and a third station attempts to call up Station No. 1 or No. 2, both bells will ring, since they are in parallel, provided that the resistances of the two circuits do not differ greatly and that the battery will furnish enough current to ring both bells.

The bells could be arranged so that the bells at both the calling and called station would ring. The way to do this would be to insert a bell with a vibrator in series with the battery, CB, between the negative pole of the battery and the connection leading to the common return wire. If the ringing of this bell is objectionable the gong or hammer or both may be removed, retaining the vibrator however. Then remove or short-circuit the vibrators of all of the station bells and insert the bell at each station between the key, K, and the individual wire, instead of in its present position, and connect the under contact of the hook switch directly to the upper contact of the signalling key. Then the vibrator in series with the battery will interrupt the current for any other station bells that may be thrown in series with it. The battery, CB, must then be strong enough to ring three bells in series.

An objection to this and many other systems, especially where vibrating bells and a common calling battery is used and where there are many stations, is found in the fact that where many of the selective switches are carelessly left off the home button there are so many bells in parallel that the current is sub-divided to such an extent that the bells will not ring or else the battery must have much more capacity than would otherwise be necessary if the switches had been properly returned to the home button. Another objection, due to the same carelessness in leaving the switch off the home button, is that the talking current has so many bells to leak through, if enough of the switches happen to be left off the home buttons and on the buttons belonging to either of the two telephones between which the conversation is to take place, that it may be impossible to carry on a conversation successfully.

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THE ELECTROLYTIC PRODUCTION OF SODA AND CHLORINE.

BY JAMES F. HOBART.

In order to separate the chlorine and sodium during electrolysis, there must be some division between the electrodes which is impervious to solutions of chlorine or soda, but not to electricity. It is then absolutely necessary to divide the cell into two parts with some good conductor of electricity between them. The dividing line between the soda and chlorine may be a horizontal one and the difference in the specific gravity of the two products taken advantage of to separate them as fast as they are made. Chlorine is a gas, and although very heavy, it is lighter than brine; therefore it rises to the surface of the electrolyte when liberated at the anodes, which are located in the upper part of the electrolytic cell, while the heavier soda enters into solution and sinks to the bottom.

Fig. 9 shows a single fluid electrolytic cell, or one without a diaphragm. Only the principle is shown in the engraving, the details being omitted. In the single fluid cell, as above stated, gravity serves as a diaphragm, except when the ions are allowed to recombine themselves; but that is not desirable in this case, hence the necessity for a diaphragm or its equivalent.

Besides the single fluid cell there is the double, also the triple fluid cell, each having advantages, all of which will be discussed farther along. In studying the "points" of a single fluid cell, as shown by Fig. 9, it is first in order to examine the required construction of the cell. It is not necessary here to go into a detailed description of a single fluid cell, save to state that the carbon plate forming the anode is 9x9 ins. square (the exposed part) and 1 in. thick. Carbon rods may be used for the anodes; they are cheaper, will not buckle, and if one or more break they may be easily replaced, and at a less cost than if a single plate had to be removed.

We have, then, $9 + 9 + 1 + 1 = 20 \times 9 = 180$ sq. ins. of carbon surface exposed to the electrolyte, which, as shown by the plan view at a, is 3 ins. deep all around the plate. The tank in which the carbon plate stands is made of iron and serves as the cathode, being directly connected in the electrical circuit as shown. As seen in the engraving, the tank has a cover which fits over it by means of the water seal shown at b, b. Another tank is built into this cover and extends, as shown, down and below the surface of the electrolyte in the iron tank. Another water-sealed cover is fitted to the top of this inner tank at c, c, through which the pipe, e, is admitted to carry off the chlorine.

When in use the electrolyte is kept about on a level with the top of the carbon plate. It will do no harm if it is a little higher, but if the level falls below the top of the carbon plate as much surface will be lost as projects above the electrolyte, thus reducing the capacity of the apparatus. With this tank, the atomic resistance figures as follows: From the table given in the May issue of The American Electrician[*] it is found that a saturated solution of chloride of sodium (Na Cl) has an ohmic resistance of 5.3 ohms per cubic centimeter, at 13 degs. C. (55.4 degs. Fahr.). Three inches, or about 8 cm., give a total resistance of $5.3 \times 13 = 68.9$ ohms, but this is to be divided by the number of centimeters in the cross-section of the electrolyte. Calling the 9 ins. the depth of the plate (carbon) to be 23 cm., and the exposed surface of 20 ins. to be 50 cm., we have a cross-sectional area of $23 \times 50 = 1150$ cm. This reduces the total ohmic resistance from 68.9 ohms to $68.9 \div 1150 = .599$, or about .06 ohm.

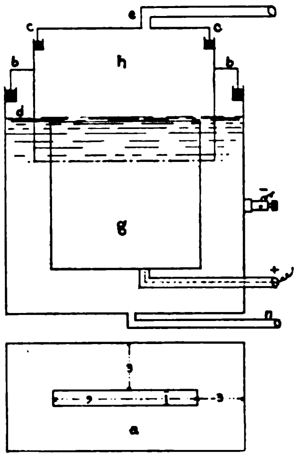

FIG. 9.—SINGLE FLUID CELL.

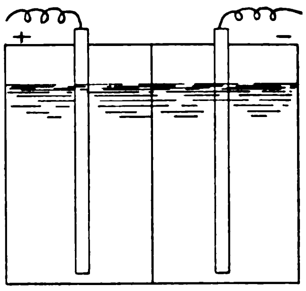

FIG. 10.—DIAPHRAGM CELL.

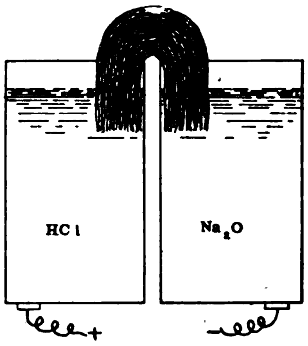

FIG. 11.—PRINCIPLE OF DOUBLE FLUID CELL.

There is also the counter e.m.f. which acts as resistance and should be added to it. This force is caused by the electrodes trying to act as a battery. Just as soon as current passes and the molecules become polarized, as described in the June issue, their tendency to reunite actuates a current ranging in power between 1 and 2 volts. To be on the safe side, it will be estimated that this "back pressure" is 2 volts. As it will require 2 volts extra in the current to neutralize it, we simply add 2 ohms more to the resistance of the cell.

The entire resistance of the electrolytic cell illustrated by Fig. 9 may then be taken at 2.06 ohms. The superficial area required for any electrode ranges from 50 to 300 sq. cm. of surface to each ampere of current. The smaller surface will deposit the greater amount of metal when electro-plating, but the larger size has great advantage in electrolysis by allowing the collection and dispersion of air bubbles without cutting down the effective plate area so that the resistance is increased to an injurious extent.

The current allowed in any conducting wire should not exceed 2000 amperes per square inch of sectional area; indeed it is better to limit conductors for electrolytic current to 1000 amperes per square inch. The total amount of copper involved in the question is too small to be a factor.

We are now in position to see what can be done with the cell shown in Fig. 9, by both extremes of area, namely, 50 and 300 square centimeters per ampere. There being about 1150 square centimeters, the current taken care of could vary from 3.8 to 23 amperes. Taking the latter current, the conducting wires should be of No. 7 copper wire, .17841 in. in diameter, having a resistance of .34120 ohm per 1000 ft. Such a wire would carry about 35 amperes, with a rise of temperature of not above 20 degs. Fahr.

Working under the above-mentioned circumstances, a certain quantity of Na Cl should be decomposed per hour, and this quantity is easily found by the methods described in the preceding papers. By revising the methods of figuring it can be determined how much current it will require to electrolyze a certain quantity of sodium in a given time.

If $C =$ current in amperes
$T =$ the time in seconds.
$C.\ T. = Q =$ quantity in coulombs.
$z =$ the electrochemical equivalent (see table May issue)
$w =$ the weight in grams of the ion liberated; then
$w = CTz = Qz$.

Therefore the weight of metal deposited from a solution of any of its salts by a current of C amperes in T seconds is $w = CTz = .000010384\ CaT$, where a is the chemical equivalent of the metal.

As determined in a previous paper, there are 238.07 grams of sodium (Na) in 1 lb. of salt (NaCl); then to reduce 238.07 grams with 23 amperes of current will require the time equaled by T in the formula, after having substituted all known quantities as follows:

$238.07 = 23\ T\ .00023873$, or
$238.07 = .000010384 \times 23 \times 22.99\ T$
$T = 43{,}200$ seconds, or 12 1/36 hours.

To do this work in one hour would take about twelve times 23 amperes—276 amperes to electrolyze 1 lb. of salt in one hour. This agrees very closely with the figures given in a previous paper.

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[*] In the extreme right-hand column of this table there occurred several typographical errors. The logarithms 2.572709; 1.934055; 1.5847138; 1.843131; 1.4746648; 1.349367; 1.852795; 1.7751534; 1.7624274 and 1.251955 should have negative indices instead of positive.

Theoretically, the single fluid electrolytic cell works all right; the chlorine goes up into the dome and the soda settles to the bottom of the tank to be drawn off through the pipe, f, at will. But practically there are several things to interfere with the successful working of the apparatus. During the passage of chlorine from the cathode, g, to the dome, h, considerable chlorohydric acid is formed, owing to the chlorine having such a tremendous affinity for hydrogen that it abstracts that element during its passage (the chlorine) through the electrolyte.

By this occurrence the top layer of the liquid becomes heavily charged with HCl, and the supply soon extends to a point considerably below the inner dome or tank; then the HCl gets at the anode tank and attacks it, besides entering again into combination with the sodium solution. In other words, the products of dissociation (ions) become contaminated with the alkali salt (electrolyte) and what is called secondary electrolysis must be employed, which calls for a separate tank or vessel for each electrode, as shown by Fig. 10. There are a great many forms of this kind of electrolytic cell. The principle is illustrated by taking two tanks, the anode of carbon in one, the cathode of iron in the other, or two tanks of carbon and of iron may be used.

Some fibers of cotton are wet with NaCl solution and dipped into both tanks, as shown by Fig. 11. When current is passed through the solutions the Cl goes to the carbon tank, while the Na passes into the iron tank; thus each ion is kept from contamination with the other. There is also a three-fluid method of electrolysis, whereby each ion is kept free from contamination, both from the other ion, and from the alkali salt (NaCl). In this method three tanks or cells are used, something as shown by Fig. 12. Here, the salt, NaCl, is placed in the middle tank, and some water acidulated with HCl is placed in the anode tank, while a solution of caustic soda is put into the cathode tank or cell. Just enough of each element is used to render the water conductive to electricity.

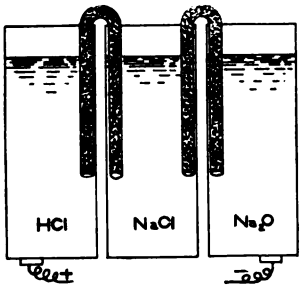

FIG. 12.—TRIPLE FLUID ELECTROLYTIC CELL.

In Fig. 12 the wick conductors are dispensed with, and in their place glass or earthen tubes are used. The siphons must be made of some non-conducting material and filled with crushed coke, carbon or some other porous conductive material. In the form of tank shown by Fig. 10, where a diaphragm is used, the great trouble is to keep the diaphragm in order. It will disintegrate by constant use, and cause a good deal of trouble by getting out of shape or "buckling" under the influence of the electric current.

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GROUNDED CARS AND DEAD RAILS.

BY E. C. PARHAM.

One of the most annoying troubles to deal with in city traffic is dirt on the rail. Out-of-town districts do not give so much trouble, for, as a rule, the T-rail is used there and the head will not hold dust. Unpaved streets in towns and smaller cities, however, in summer time give the motorman trouble. Whenever a car gets high and dry on the dust so that sufficient current cannot get through to start, the motormen, as a rule, say the car is "grounded." On the contrary, the fact is that the car fails to start because it is not grounded. When the dust gets very thick on the rail there is a complete layer of dust between the rail and the wheels; dry dust will not carry a current, so the motor circuit is practically open and no current can get through. The voltage is there, though, charging the wheels, the brake-handles, the guard rails, fender and grab handles, ready to send a current through the first person or thing that offers a path to the rail. The whole metal work of the car is in condition to deal heavy shocks to a person getting on or off, unless he or she knows how to do it. Pulling one or both of the hood switches does not help matters any if either the heater or lamp circuit is tapped on beyond these switches. The heaters are not, as a rule, so connected, but the lamps always are, and the first thing the crew does when the car fails to start is to turn on the lamp switch to see if the line is "alive" or not. The switch is generally left on until the car starts.

The only way to "kill" a car in this condition to a certainty is to pull down the trolley pole. The first indication that a car is "grounded," or more literally, "dusted," is that it refuses to start after being stopped in a dusty place. A car will run through almost any amount of dust, with the motors in multiple, because after the flow of current is once started it will hold an arc through the dust from each wheel to the rail, and enough current goes through these arcs to keep the car moving. But while the trolley voltage is sufficient to support an arc when once started, it cannot start one through the dust, if the car is once stopped. The moral to draw from this fact, then, is to keep the car moving till it comes to a place where at least one of the rails is fairly clean. A stop should never be made on dusty rails if it can be avoided. Better take one passenger past his corner and accept his abuse gracefully than stall the car and invite the abuse of the whole load. A car is seldom so badly "grounded" but that the lamps will show a very dim red. If the car refuses to move and the lamps show a dim red, therefore, it is almost proof positive that the trouble is due to dust, unless there are other symptoms to indicate some other trouble elsewhere.

As soon as it is suspected that the car is "grounded," no one should be allowed to get on or off, as a severe shock can be gotten by doing so; nine out of every ten persons in getting on or off retain a hold of the grab handle or dash rail at the same time that their feet are on the ground, so the live car can send a current through them to the earth. If the car has an iron step it is often only necessary to have one foot on the step and one on the ground in order to get knocked down. Passengers should be instructed under such conditions that the safe way to get on and off the car is to jump so that both feet are in the air at the same time, and to strictly avoid touching any part of the metal work of the car with the hand. The line voltage may not send current enough through the dry earth to start the car, or even to light the lamps, but it will send enough to shock a person most severely.

Having decided beyond a doubt that the car is "grounded," the next thing to do is to get it moving. Before taking any steps to this end, the trolley pole should be pulled down, then no one can get hurt. This done, if possible get a can of water and douse the rail off just ahead of one of the wheels; sometimes water is hard to get, in which case clean the rail off as well as possible with a switch iron and then jam the switch iron in between the rail and the wheel; next put the trolley on the wire and go back to where the switch iron is, so that when the car starts you can grab the iron and jump on without stopping the car again to perhaps repeat the operation.

If it should be preferable to start without pulling down the trolley pole, slide the switch iron along the rail toward the wheel, cleaning off the rail; then jam the iron up under the wheel, bearing down on the rail at the same time. As long as the switch iron makes good contact with the rail there is no danger of getting a shock, but if by any hook or crook the switch iron should touch the wheel without touching the rail, the current will pass from the wheel along the switch iron to the hands and through the body to the earth. The best and safest way to avoid all danger, therefore, is to pull down the pole while you work.

A dead rail is very much akin to a dusty rail in effect. It is harder to locate, because it shows up so seldom that it may be some time before it is suspected. A dead rail is due to the bond-wires coming loose or breaking at both ends of it, so that no current can get from it to the abutting rails. On modern track work trouble due to a dead rail is rare, because not only are all the bonds on the same side of the track connected together, but those on opposite sides are also, by a bare wire that zigzags down the track from one side to the other. In order for a car to be "killed" by broken rail-bonds, two rails opposite each other must be dead. In such a case the speed of the car is checked when running over the dead section with the power on, and at night a bright flash will be seen when the rear wheels pass onto the dead section. To start a car on a dead rail, stick the switch iron down between the end of the dead rail and the rail next to it. This gives the car a ground.

SURFACE CONDENSERS.

BY JAMES F. HOBART.

The object of a condenser attached to a steam engine is twofold. It adds to the power of the engine by utilizing a considerable portion of atmospheric pressure, thereby increasing to a considerable extent the force applied to the piston. The condenser also enables the same water to be used over and over again in the boiler. This point may be neglected in stationary engine practice, where plenty of feed water is available. If it were possible to completely condense the cylinder-full of steam at the end of a stroke, there would be exerted a "suction" of about 14.7 pounds per square inch to pull the piston back. This is added to the steam pressure exerted upon the other side of the piston.

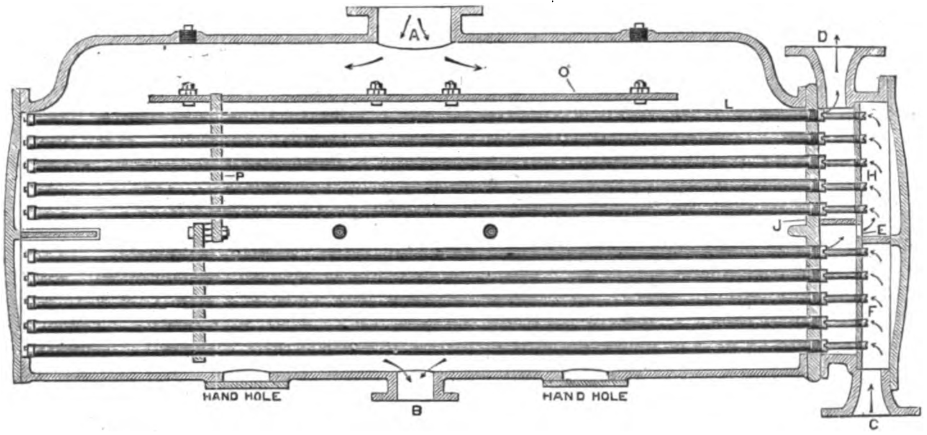
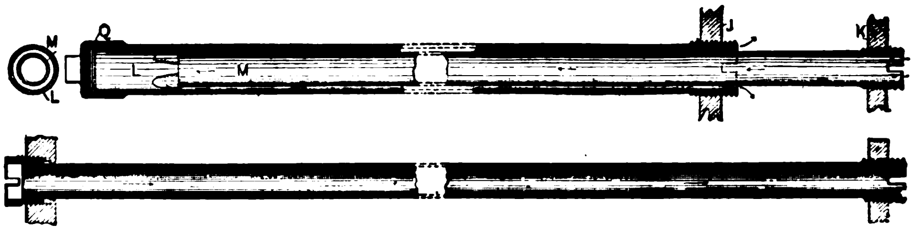


FIG. 1.—WHEELER CONDENSER

In early condensing practice, the engine exhausted into a closed vessel in which there was a spray of water which condensed the steam very quickly. The injection water and the water of condensation were then withdrawn by a pump, and the desired partial vacuum was maintained. But it was not always found convenient to handle or use the large body of water removed by the air pump. When salt water had to be used for cooling, the water of condensation could not be used again, therefore some method was looked for which would return the steam condensed and without contamination. This resulted in the production of the surface condenser, which is structurally similar to a feed-water heater, cold water being used inside of the tubes, instead of steam. In the earlier forms of surface condensers, the tubes were put through two heads, one at either end, and water circulates through the tubes from one end of the device to the other, being kept from direct contact with the steam by means of the heads outside of which are receiving and delivering pipes. In this form of condenser there has always been great trouble in keeping the tubes tight. Expansion caused trouble when the tubes passed through the heads, and leaks in the packing were very common occurrences.



FIGS. 2 AND 3.

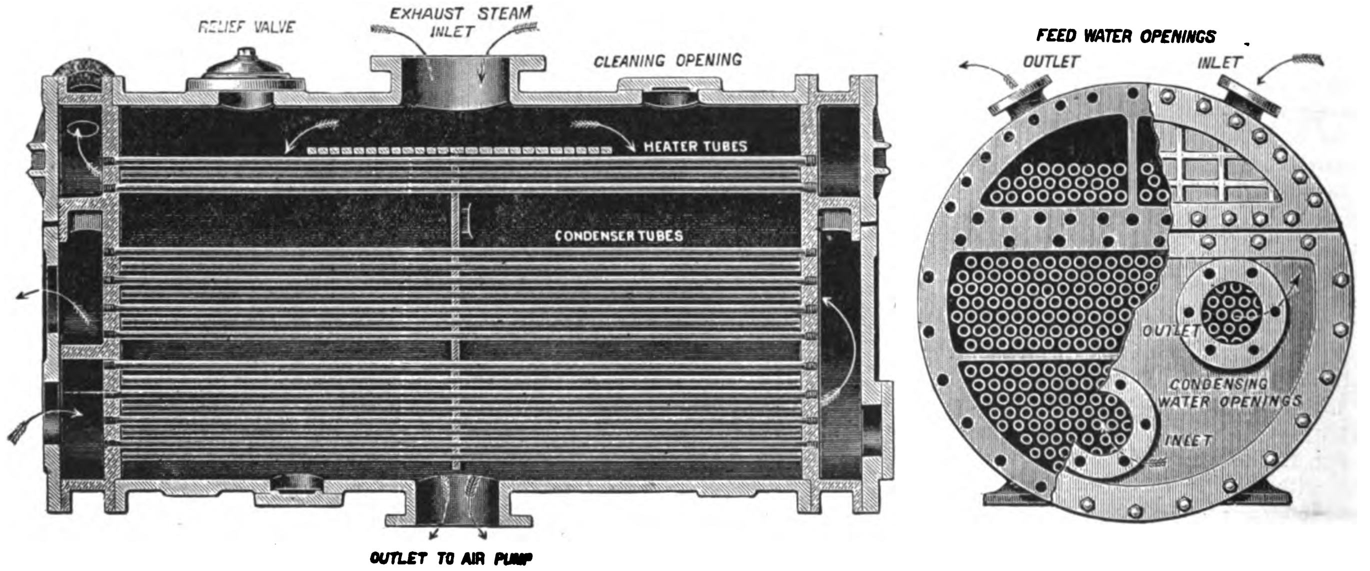


FIG. 4 —VOLZ COMBINED SURFACE CONDENSER AND FEED-WATER HEATER.

To obviate this difficulty the form of condenser shown by Fig. 1 was devised. Here, the tubes are attached to their respective heads, are free from packing of any kind, and are free to expand at will without danger of forming leaks. The method of attaching these tubes and the manner of their arrangement are plainly shown by Fig. 2. Here, one tube has a cross-sectional area of twice the area of the outer or larger tube. They are screwed solidly into their respective heads, and are there to stay. To make clearer the advantage of this form of tube, a detail of the old form of tube is shown by Fig. 3. Here, one end may be rigidly attached to a head by being screwed therein, while a ferule and packing makes the other end tight. This form is known as the Wheeler-Admiralty tube, and differs from the ordinary type, which is a plain tube with ferule packing at each end. The arrangement of the double-tube condenser is such that the circulating water, leaving the condenser at a high temperature, encounters the hottest steam at that point, thus obviating the possibility of any danger of reheating through poor circulation in the condenser. This type of condenser is made by several concerns, the original Wheeler patents having expired. The engravings shown above, however, as well as that shown by Fig. 4, represent the product of the Wheeler Surface Condenser & Engineering Company, of New York.

Fig. 4 illustrates a combination device which not only condenses the exhaust steam but also uses a portion of the heat therein contained for heating the feed water. Engineers using surface condensers are aware of the difficulty of obtaining feed water from the hot-well at or near the proper temperature due to the vacuum in the condenser, particularly in cold weather when the circulating water averages a low temperature. The water of condensation is continually losing its heat on account of the radiation from pipes and other surfaces as it passes from the condenser through the air pump, thence to the hot-well, and finally, through the feed pump and pipe connections. Therefore, a simple, compact and effective method of heating the feed water is of great importance, not only to insure maximum fuel economy, but to prolong the life of the boiler. The "Volz" system is designed to meet this want, by reason of simplicity, comparatively small cost, and the maintenance of high vacuum, irrespective of hot-well temperature. As will be seen by Fig. 4 the upper part of the shell or exhaust steam chamber contains the feed-water-heating tubes, while the lower part contains the condensing tubes, each being in communication with their respective water chambers. The heater tubes, being located in the upper part of the condenser, are exposed to the hottest steam. The feed water is, therefore, heated to the same temperature as that of the exhaust steam.

The first requisite of a surface-condensing plant is a plentiful water supply. There is, however, an appliance for cooling the circulating water so that it may be used over and over again continuously. Fig. 5 illustrates an apparatus of this kind, called the Barnard cooling tower, also made by the firm noted above. In the illustration the cooling device is shown located upon the roof of a building about (in this case) 90 feet above the condenser. Practically there is no limit to the height at which the tower may be located, as the only additional work put upon the circulating pump is to overcome the slight friction of the water in the vertical water pipes; this is because the two columns of water very nearly balance each other. The cooling process is effected by exposing the water to a large volume of air, supplied by means of the motor-driven fan blower shown in the illustration. It is essential in a machine of this kind that the cooling surface be sufficiently large to cool the required quantity of water to the required degree. This is a mere question of figured capacity, and has nothing to do with the principle involved, which in reality is a system of compound cooling, the heat being transferred first from exhaust steam to water, and thence to air, of which there is an unlimited supply. Really, then, in this system, air is utilized instead of water, as a heat-disperser, and the heat removed goes into the atmosphere direct from the cooling tower instead of indirectly from a river, lake or ocean.

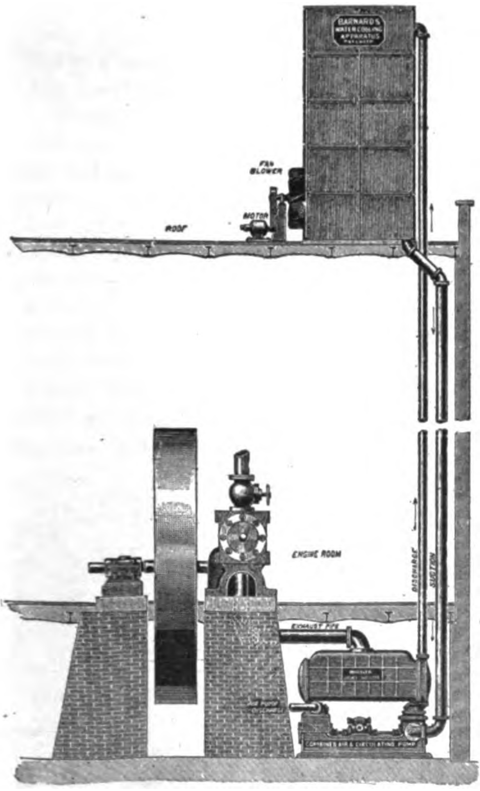

BARNARD'S WATER COOLING APPARATUS
FAN BLOWER
MOTOR
ROOF
ENGINE ROOM
DISCHARGE
SUCTION
EXHAUST PIPE
COMBINED AIR & CIRCULATING PUMP

FIG. 5.—BARNARD COOLING TOWER.

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Lessons in Practical Electricity

IRON LOSS IN TRANSFORMERS.

The loss in watts per cubic inch of iron in a transformer core due to hysteresis is given by the formula

$$\frac{2.75 \times n \times B^{1.6}}{10,000,000,000} = P_h \quad \text{.................} (6)$$

in which 'n' is the frequency and 'B' is the maximum magnetic density in lines of force per square inch of core cross section. The expression $B^{1.6}$ means the 1.6 power of B, and is an inconvenient factor for learners to deal with.* The accompanying table gives the 1.6 power for various values of B and also gives the loss in watts per cubic inch of core iron corresponding to these values and to a frequency of one cycle. For other frequencies it is only necessary to multiply the tabular value by the frequency.

HYSTERESIS LOSS PER CYCLE.

Values of B	$B^{1.6}$	Watts per cub. inch.
18,000	6,433,300	0.0018
20,000	7,614,600	0.0021
22,000	8,869,000	0.0025
24,000	10,194,000	0.0028
26,000	11,586,500	0.0033
28,000	13,045,300	0.0036
30,000	14,568,000	0.0041
32,000	16,152,600	0.0045
34,000	17,797,800	0.005
36,000	19,502,200	0.0055
38,000	21,264,500	0.006
40,000	23,083,200	0.0065
42,000	24,957,400	0.007
44,000	26,885,900	0.0075
46,000	28,867,800	0.0081
48,000	30,901,900	0.0086
50,000	32,987,700	0.0092
52,500	35,600,000	0.01
55,000	38,422,000	0.0108
57,500	41,254,200	0.0115
60,000	44,161,300	0.0124
65,000	50,195,100	0.0140
70,000	56,514,100	0.0158
75,000	63,110,000	0.0177
80,000	69,975,200	0.0196
85,000	78,175,400	0.0219
90,000	84,486,600	0.0236
100,000	100,000,000	0.028
110,000	116,574,000	0.0326
120,000	133,872,000	0.0375

As the core-loss current, h, in a transformer is in phase with the primary reduced e.m.f., E_0, when the core loss in watts is known the core-loss current, h, may be found by dividing the core-loss in watts by the induced primary e.m.f. E_0. The magnetizing current being ascertained by formula (5), the exciting current, C, is obtainable by combining the magnetizing current, M, and the core-loss current, h, according to the formula

$$\sqrt{M^2 + h^2} = C \quad \text{......................} (7)$$

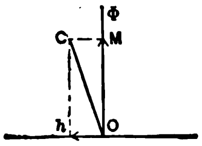

FIG. 11.—SHOWING THE DIFFERENCE OF PHASE BETWEEN THE MAGNETIC FLUX AND THE EXCITING CURRENT DUE TO HYSTERESIS AND EDDY CURRENTS.

As an example, let us suppose that a transformer designed for use on a 1000-volt 60-cycle circuit has a magnetic density of 40,000 lines of force per square inch and 1560 turns of wire in the primary winding. We will also suppose that the length of the magnetic circuit is 24 ins. and the area of the core is 6 sq. ins.; then, according to formula (5)* the magnetizing component of the current will be 0.64 ampere. According to the table, at a density of 40,000 the loss in watts per cubic inch and per cycle is 0.0065, and as there are 144 cu. ins. and 60 cycles, the hysteresis loss will be 56.2 watts. The induced e.m.f. of the transformer being practically 1000 volts, the core-loss current will be 1/1000 of the number of watts or 0.0562 ampere. Combining the magnetizing and core-loss currents according to formula (7), the result is about 0.6425 ampere for the primary exciting current, or 1002 ampere-turns for the primary exciting force.

These calculations are based upon the secondary circuit being open, but it makes practically no difference whether this circuit is open or closed as to the amount of exciting force required by the core. The effective number of ampere-turns must remain the same whether the secondary circuit be open or closed, consequently, when the secondary circuit is closed and current is allowed to flow through the secondary winding, the amount of current which will flow in the primary winding will be such that the effect of the primary ampere-turns will be just enough greater than the effect of the secondary ampere-turns to give, net, the exciting force required when the secondary is open.

If the phase of the current flowing in the secondary when that circuit is closed were precisely opposite to the phase of the pri-

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*The 1.6 power is found by the arithmetical formula:
$1.6 \times \log B = \log$ of 1.6 power.

*Formula (5):

$$\frac{B \times L}{10,000\ N_p} = M.$$

L = Length of magnetic circuit,
N_p = Number of primary turns,
M = Magnetizing current.

mary current, then the current would increase in the primary winding until the total primary ampere-turns exceeded the total secondary ampere-turns by exactly the amount necessary to magnetize the core and supply the core-loss. As an illustration, in the foregoing example the primary ampere-turns necessary for magnetization and hysteresis loss were 1002. Supposing the transformer to have a ratio of 10 to 1, the secondary winding would contain 156 turns. If now the secondary circuit be closed and the current flowing in that circuit were 20 amperes, the secondary ampere-turns would be 3120, consequently the primary current would increase until the primary ampere-turns reached 3120 + 1002 = 4122 ampere-turns.

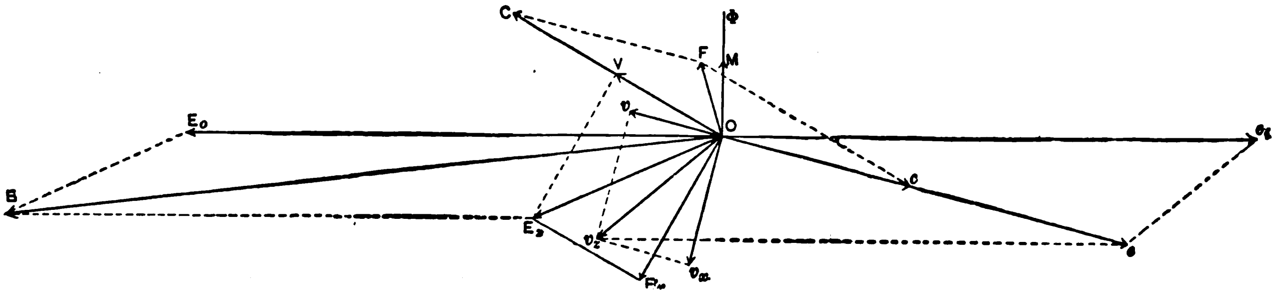

FIG. 16.—COMPLETE DIAGRAM OF PHASE RELATIONS WITH A NON-INDUCTIVE LOAD ON THE SECONDARY.

As a matter of fact, however, the phase of the secondary current is not squarely opposed to that of the primary, so that a given number of ampere-turns in the secondary will not entirely neutralize the same number of ampere-turns in the primary; consequently, the primary ampere-turns do not need to exceed the secondary ampere-turns numerically to the full extent of the exciting ampere-turns.

The amount by which a given number of secondary ampere-turns fails to exactly neutralize an equal number of primary ampere-turns (due to the fact that the two phases are not precisely opposite) is practically sufficient to supply the exciting force necessary for the core, so that for all intents and purposes the current in the secondary at any load may be considered as equal to the current in the primary multiplied by the ratio of transformation, the latter being called equal to the ratio of primary to secondary turns.

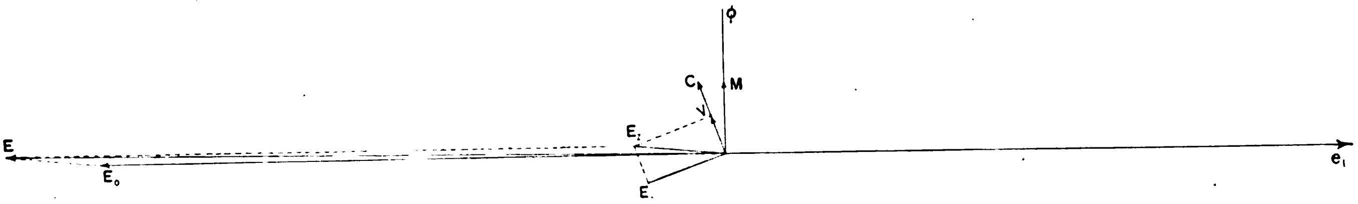

FIG. 19.—COMPLETE PRIMARY PHASE RELATIONS, WITH THE SECONDARY CIRCUIT OPEN.

The diagrams here given, showing the phase relations, are plotted as though the primary and secondary windings had the same number of turns, in which event the primary induced e.m.f., E_0, would be exactly equal to the secondary induced e.m.f., e_1, as shown in Fig. 16, for the reason that the variations of the one flux in the core induce both of these e.m.fs. It is evident, therefore, that the relation between the primary and secondary induced e.m.fs. is precisely the same as the relation between the turns in the two windings, and as in actual practice the primary induced e.m.f., E_0, is so nearly equal to the impressed e.m.f., E, that the two are considered numerically the same, it can be further considered that the numerical relation between the impressed e.m.f., E, and the secondary delivered e.m.f., e, with the secondary circuit open, is the same as the relation between the turns in the primary and those in the secondary windings.

When the secondary circuit is closed, however, this relation can no longer hold good rigidly because of the losses in the two windings. The loss in the primary windings increases the difference between the value of the primary induced e.m.f., E_0, and the primary impressed e.m.f., E, to a slight extent. The reason for this will be evident upon reference to Figs. 16 and 19. The former is a diagram of phase relations with the secondary closed through a non-inductive load, and the latter is a diagram of primary phase relations with the secondary circuit open.

It will be noted that in the latter case the length of E_0 is greater than in the former, the length of the vector, E, indicating the impressed e.m.f., being the same in both diagrams. This increases the ratio between the impressed e.m.f., E, and the secondary induced e.m.f., e_1. Furthermore, the loss in the secondary winding reduces the available secondary e.m.f., e, below the value of the secondary induced e.m.f., e_1, so that the ratio between the impressed e.m.f., E, and the secondary delivered e.m.f., e, is still further increased. At full load, therefore, the ratio between the impressed e.m.f. and the delivered secondary e.m.f. will not be exactly the same as the ratio between the two windings of the transformer.

All of the preceding remarks apply to a transformer supplying a non-inductive secondary load; putting an inductive load on the secondary still further changes the phase relations and ratio of transformation; this will be explained in a succeeding lesson.

Letters on Practical Subjects

The Effect of Cleaning a Commutator Upon the E.M.F. of a Dynamo.

To the Editor, American Electrician;

Sir:—Among other dynamos under my care is a multipolar direct-current compound-wound machine giving 160 kilowatts at 125 volts, which manifested the peculiarity of "creeping up" in voltage after continued running and shows a drop of about three volts immediately after cleaning the commutator. Vaseline is used in wiping the commutator. One would naturally expect that the voltage would drop as the commutator became dirty and would rise correspondingly when the commutator was cleaned, but this was not the case. The current output remained the same during the several observations.

My own explanation of the contradictory action of the machine is that after the commutator has been running some time the vaseline becomes sticky, and since the brushes fit loosely in the holders the sticky commutator surface drags them forward, lifting the forward brush edges clear of the commutator and throwing the lead backward a trifle; the rheostat is adjusted to give the right e.m.f. under this condition. Upon applying fresh vaseline the commutator surface becomes less sticky and the brushes resume their normal position, throwing the lead forward and lowering the voltage.

I would be glad to have any of your readers express opinions as to whether my explanation is correct, and if it is not, to suggest a more logical reason for the drop in voltage when fresh vaseline is applied to the commutator.

Frank Farmer.

New York City.

Grounding Interior Conduits.

To the Editor, American Electrician;

Sir:—Referring to Mr. Alfred W. Watkins' letter on the "Grounding of Interior Conduits," in your June issue, it is a noticeable fact that the grounding of the conduit is largely disregarded and I am unable to see a good reason why it should be grounded at all. A case which came to my notice recently in which the grounding of the conduit would have been a disadvantage. The building was wired with unlined conduit and all work complied with the underwriters' rules with the exception of the grounding of the conduit, although the conduit became grounded in some way after the work was completed. The wall switches were of an approved type, being double-pole flush switches, the underwriters specifying double-pole switches where the circuit carries over six lamps. The lug which fastens the switch to the wall, or to the switch box in conduit work, was not more than one-eighth inch from the electrical connections of the switch. During thunderstorms it was found that the lightning discharges would jump across this space on their way to the ground, and of course, the incandescent current followed. It was found that several of the switches were dangerously hot, and had to be replaced with new ones owing to the brass and porcelain being melted and run together.

It appeared to me that mounting switches and rosettes on an iron box which is effectually grounded is not the best practice.

J. B. Stewart.

Hot Springs, Va.

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Testing Damaged Armatures.

To the Editor, American Electrician;

Sir:—Having had trouble with the armature of a 15-h.p. 220-volt direct-current motor, and not having a good voltmeter, I used the following method of testing, which may interest some of your readers. I ran two test wires from a 110-volt 125-cycle alternating-current circuit and in series with one of them connected a 16-c.p. incandescent lamp. On applying the wires at opposite points of the commutator, the lamp only gave about half its normal candle-power; this was due to the inductive choking effect of the armature winding, as the resistance was only 0.25 ohm. On touching the wires to the commutator at points 90° apart, the lamp became dimmer, showing that the burnt-out coil was within the 90° section between the wires. By bringing the wires closer together we located the coil that was burnt out. When the wires were on the adjacent bars of the open coil there was only one path for the current, which was through the rest of the armature (see Fig. 1); the choking effect dimming the lamp to a dull red. Therefore this showed that the coil between these two adjacent bars was burnt out.

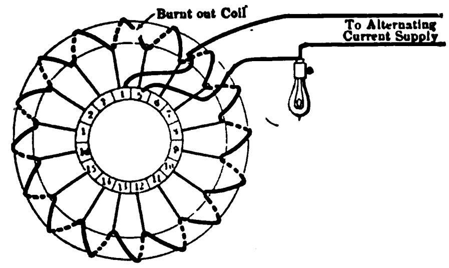

FIG. 1.

To test for a short-circuit between two adjacent segments, use a bank of lamps in place of the single lamp, and use enough lamps so that when the test wires are applied to two adjacent bars (which are all right) the lamps do not give more than one-half the normal candle-power. Now test each pair of segments. On touching a pair that are short-circuited, as in Fig. 2, the lamps will burn at full candle-power.

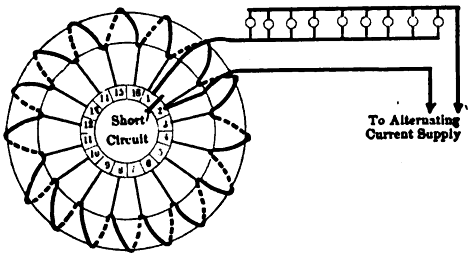

FIG. 2.

Hugo Altmayer.

San Francisco, Cal.

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Electrical Catechism

504. How can the resistance of a wire be determined?

The simplest way is to test its size by a wire gauge and find the resistance from a table. Instead of using a wire gauge, the diameter may be measured by a micrometer, and the resistance may then be calculated or may be taken from a table.

505. How can the circular mils in a wire be calculated from its diameter?

When the section of a wire is circular, the area equals the diameter squared. By geometry it is shown that the areas of circles are to each other as their diameters squared. Taking the area of a circular mil as the unit, the area of any round wire equals the square of its diameter measured in thousandths of an inch; thus the area of a wire having a diameter of 102 thousandths of an inch is 102 × 102, or 10,404 circular mils.

506. How can one calculate the number of circular mils in a bar of rectangular section, such as a bus bar?

It is most easily calculated by remembering that one square inch equals 1,273,000 circular mils. Therefore, find the area of the bar in square inches and multiply by 1,273,000, and the result will be the cross section in circular mils.

507. How can the resistance be calculated when the diameter and length are known?

The resistance of a wire equals the resistance of a circular mil-foot multiplied by the length in feet and divided by the number of circular mils in its area, or divided by the square of its diameter in thousandths of an inch. Thus, the resistance of a copper wire 0.102 inch in diameter and 1,000 feet long is

$$R = \frac{10.5 \times 1000}{102 \times 102} = 1.01 \text{ ohm.}$$

In practice it is common to take 11 as the resistance of a mil-foot of copper, thus making some allowance for impurity in the wire and for imperfect connections. The rule is often written as a formula:

$$\text{Resistance} = \frac{11 \times \text{length}}{\text{diameter squared}}, \text{ or}$$

$$R = \frac{11\,L}{d}.$$

508. How can the size be determined to give a certain resistance in a copper wire of a certain length?

The formula in No. 507 can be easily changed, showing that the area in circular mils or the square of the diameter of the wire equals the length multiplied by the resistance per mil-foot, divided by the required resistance; or,

$$\text{c. m.} = d^2 = \frac{L \times 11}{R}.$$

509. Give an example showing how the formula is used.

A wire one mile long is required to have a resistance of 2 ohms.

$$\text{c. m.} = \frac{5280 \times 11}{2} = 28{,}000 \text{ circular mils:}$$

this is a little larger than No. 6 B. & S. gauge. If it were necessary to make the line have the exact resistance stated, it might be made partly of No. 6 and partly of No. 5.

510. How can one calculate the length of wire necessary to give a desired resistance?

The length equals the resistance multiplied by the square of the diameter and divided by the resistance of a mil-foot, or

$$L = \frac{R\,d}{k}.$$

511. What must be the length of a German silver wire 0.016 inch in diameter to make 200 ohms?

The resistance of a mil-foot of German silver is about 127 ohms, varying to some extent in different lots. For 200 ohms the required length is

$$L = \frac{200 \times 16 \times 16}{127} = 403.1 \text{ feet.}$$

512. What is the resistance of 100 feet of "EBB" telephone wire 0.064 inch in diameter?

Resistance equals the resistance of a mil-foot multiplied by the length and divided by the area or by the square of the diameter. The resistance of "EBB" iron wire is 65.3 ohms per mil-foot at 75 degrees Fahrenheit. Therefore,

$$R = \frac{65.3 \times 100}{64 \times 64} = \frac{6530}{4096} = 1.6 \text{ ohms.}$$

Queries and Answers

Will it injure a storage battery to allow its temperature to descend to the freezing point? D. W. M.

Not necessarily, but it is not good practice to permit the temperature to go so low.

How can I reverse the direction of rotation of a motor armature?
J. F. C. M.

Exchange the connecting wires or leads attached to the brush-holders. If the machine has radial carbon brushes they will not need any adjustment, but if it has tangential brushes of any kind these will have to be reset to avoid damage due to the reversed rotation.

Is good tool steel suitable for making permanent magnets? How should it be tempered and magnetized? (2) Is alternating current from a magneto machine suitable for igniting gas in a gas engine? A. E. B.

Yes. It can be tempered exactly as for making tools. The best method of magnetizing is to wind a coil of a great many turns around the bar and pass current through it from a dynamo. (2) Alternating current from a magneto is commonly used for igniting gas in a gas engine.

Please inform me if it is possible to operate satisfactorily compound and shunt-wound machines in parallel? T. H. C.

Yes; if the load does not fluctuate rapidly and violently. On street-railway circuits it is not always practicable to work two machines of the types mentioned in parallel, but on steady loads it can be done without any trouble whatever. In such a case the compounding coils must be shunted until the machines divide the full load equally, having been adjusted to give equal e.m.fs. at no load.

What are the phase relations in a monocyclic circuit when the teaser winding contains one-fourth as many turns as the main winding of the generator armature?
E. G. W.

Assuming that the loads in the teaser and main windings are normally proportional to each other, the current in the teaser line-wire will be 90 degrees out of phase from the current in either one of the main line wires; the current in a circuit from the teaser line to either one of the other lines will be about 26½ degrees out of phase with the current in a similar circuit extending from one to the other of the main wires.

Will adding more turns to the secondary of an induction coil increase the secondary e.m.f. and current? (2). If the secondary winding is divided into a number of sections, each having the same number of turns, will the voltage of all the sections be the same?
A. L. I.

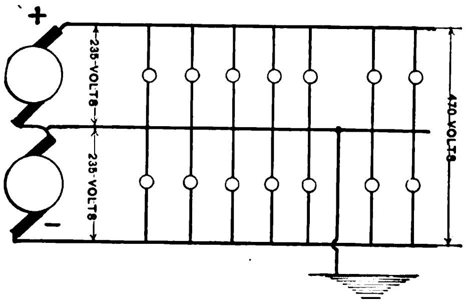
Adding more turns will increase the secondary e.m.f. but not necessarily the current. The volume of current is extremely small and depends upon the length of the spark gap and amount of leakage. (2.) If all of the turns of the secondary were equally effective the voltages of the various sections would be the same. On account of magnetic leakage from the core through the side of the coil, however, the secondary turns nearest the ends of the coil are less effective than those in the middle, consequently the end sections would not give as high a voltage as the middle ones, even though all the sections had the same number of turns.

Cannot a polyphase alternator be made self-exciting without the use of a commutator?
A. S. R.

No. Even if the field magnet responded to the fluctuations of the alternating current, the polarity of the magnet poles would be constantly reversing; whereas it is necessary for the poles to remain of fixed sign in order that the machine may be operative. Moreover, the magnets will not respond effectively to the rapid alternations.

The enclosed diagram represents a three-wire system with the neutral grounded; why do not the 235-volt lamps between the positive wire (at 470 volts) and the neutral wire (at zero) burn out? (2). What would happen if the fuse of the negative wire should blow at the station? (3). Could not the system be installed and operated more economically by simply putting two 235-volt lamps in series, and leaving out the neutral wire? (4). Will one lamp burn and give its full candle-power when operated alone on either side of the neutral? A. P. L.

Because the difference of potential at the terminals of the lamps is only 235 volts; grounding the neutral does not increase the potential between the positive wire and the neutral wire. (2). Nothing, as long as the loads are equal on each side of the neutral. If the loads are unbalanced then the lamps on the lightly-loaded side would be likely to burn out, or else those on the heavily-loaded side would grow very dim. (3). Such an arrangement would be cheaper to install, but it involves the disadvantage that the lamps must be used in groups of two instead of singly, which obviously prevents the use of any odd number of lamps, as well as the independence of single lamps. (4). Certainly.



Is there any difference in the pressure exerted on different parts of plain horizontal boilers? F. M. K.

Yes. In addition to the steam pressure there is the pressure on the under sheets of the boiler due to the weight of the water itself. The greatest pressure is exerted along a line drawn from end to end of the boiler at its lowest point; in other words, along the fore-and-aft line where the water is deepest. The pressure along this line may be found by multiplying the height of the water in inches by its weight per cubic inch at the working temperature, and adding this to the gauge pressure.

What the chief trouble is in not being able to telephone over long distances? (2). What would be a requirement of a repeater?
R. A. P.

The difficulty in transmitting speech over very long distances is that the resistance and capacity of the long line render it necessary to use a very strong battery in order that the current strength at the receiver will be adequate; and a telephone transmitter will not work satisfactorily if the battery strength is increased beyond a certain point. This limiting point is too low to give the proper results over very long lines. (2). The requirement of an ideal repeater is that it shall repeat current fluctuations from one line into another line, and at the same time with greater strength than that of the received current.

How can the brake horse-power of a steam engine be determined without the use of a friction brake? T. W. F.

Take a set of indicator cards and speed readings with the engine running under full load and another set of cards and speed readings with the engine running absolutely without load; calculate the horse-power indicated by each set of cards and deduct the smaller from the larger. The result will be the net brake horse-power of the engine at full load, subject to a very slight correction for difference in the friction of the moving parts between no load and full load; this difference is so slight, however, as to be practically negligible. The initial steam pressure should be the same throughout all of the tests, and if there is any difference in speed, all of the tests should be reduced to one speed.

We have a two-phase rotary converter which takes current from transformers; one phase takes about 3 amperes (at 2500 volts) more current than the other one does. What is the cause of this and how can it be remedied? Why is not the load exactly even on each phase? G. B. L.

There are several causes which may result in one phase of a rotary converter taking more current than the other phase. If the two phases supply lighting circuits and one phase is more heavily loaded than the other, the voltage on that phase will be a little lower; consequently the converter will take less current from that phase than from the other one. Another possible reason is that the taps leading from the collector rings to the winding are not precisely the same distance apart. The slightest difference in the number of coils between the taps of the two phases would make quite an appreciable difference in the amount of current taken by each phase. It may be also that the construction of the line is such as to give more self-induction in one phase than in the other, in which case the phase having the most self-induction in the line will deliver a lower e.m.f. to the converter and the current will be less in that phase than in the other.

STOKING AND MECHANICAL STOKERS.

BY A. L. HARRISON.

I have been much interested in the articles on steam engineering which appeared in the June issue of the American Electrician, especially the one on "Stoking in Central Stations." The use of stokers and automatic furnaces is becoming more and more to be recognized as an essential in the make-up of a modern boiler plant, and as mechanical furnaces are less known, and their advantages and operation not familiar to most of those who own or operate steam plants, it seems to me a discussion along this line might, if kept within proper bounds, be of decided practical value.

The article by Mr. James F. Hobart above referred to contains much valuable information and the cuts used are, with one exception (Fig. 1), quite faithful representations of the various forms and their respective mechanical operation. His description of the workings of the different forms, however, bears evidence of greater knowledge of what the prospectuses of various manufacturers represent than of the actual practical results experienced. It is the practical results obtained and obtainable that are of greatest interest and value to the public. I shall therefore confine myself principally to this line in this discussion.

First, however, I wish to refer to Fig. 1, representing the "Process of Combustion." According to my knowledge of the chemistry and the action of coal in a furnace, it is not practicable to feed coal through a hopper and onto grates constructed as that figure shows; nor are there any such "stages" in the process of combustion.

Fig. 2, showing the process of feeding and burning the coal in the Murphy automatic smokeless furnace is incorrect in this particular, as it represents an equal amount of flame in the furnace and in the chamber back of the arch and around the fire surface of the boiler, whereas in practice the flame is confined to a comparatively small part of the firebox at each side of the furnace near the base of the arch where the coal is fed to the grates.

The volatile gas is distilled rapidly as the coal is pushed forward on the coking plate and into the furnace, and this gas is instantly ignited and completely burned as given off from the fresh incoming fuel. It is this gas which gives what is commonly termed flame as it is consumed or burned. The coke which covers the principal part of the grate area burns with a short white flame, and the heat of the two elements combines to fill the space over the grates and within the arch with white heat.

The process of combustion, so far as it goes in each of the stokers represented, is substantially the same in all. The principles involved, viz., regular and constant feed of the coal, coking it as it enters the fire, burning the resultant gas as distilled, and also burning, in connection with it, the solid ingredient or carbon of the coal, are theoretically the same in all mechanically-fed furnaces, whatever the type or specific form. The capacity to coke the coal when a large amount is required per square foot of grate area varies, however, with the form of the furnace.

It will be obvious that the furnace having the greater length of coking or feeding surface in proportion to grate area will thoroughly coke and burn the resultant gas perfectly of a greater quantity of coal per hour than one having less coking capacity in proportion to grate area. This coking process, or thorough distillation of the volatile matter in bituminous coal before it gets far beyond the dead or coking plate, is essential to smokeless combustion and, as regards this feature, the illustrations presented seem to show that the Murphy double side-feed arrangement is superior to any front-feed form.

There are two statements in connection with the description of the front-feed "stairway" type of stoker which are liable to misleading interpretation, viz., "The doors through which inspection and cleaning, if it should be necessary, are accomplished, are below the fire, so that any air admitted cannot impinge upon the boiler without first passing through the fire and becoming heated," and "this type of stoker may be used with any kind of fuel." Now it is plain from both Fig. 4 and Fig. 5 that no cleaning, in any practical or proper sense, of the fire in that form of furnace can be accomplished except by dropping the dump grate at the lower and rear end of the furnace. It is also equally plain that when this "dump" is dropped for cleaning, the cold air must rush up directly onto the boiler surface without "passing through the fire" or "becoming heated" to any great extent.

It is also a very well-known fact that there is no "if" about the necessity for cleaning at intervals, more or less frequent, according to the quantity of ash and clinker in the coal. Furthermore, there are several kinds of fuel which cannot be used with practical success in the type referred to. I never heard of its successful use with anthracite of any grade, and certainly it would be utterly useless in burning any grade below pea size. This, however, is not a serious fault, for there is no type of stoker or mechanical furnace that will burn anthracite successfully unless made and especially adapted for that purpose. My experience is that none of the front-feed or under-feed stokers can successfully burn a low grade of soft coal carrying a large percentage of clinker.

In connection with the description of the chain-grate type, Mr. Hobart says, "There is no prying off of clinkers or digging out of ashes; absolutely nothing to do save to put the coal upon the grate, and this may be done by conveyor and the usual hopper." I can imagine better than I can describe the smile that must come over the face of every engineer and fireman who has had experience with that particular form and who reads that Munchausen claim. Another reference to chain grates is inaccurate, viz., the one claiming that the rate of combustion may be controlled by "rate of grate travel." It is quite evident that the feed of the coal as to thickness will be the same at any given adjustment of "grate" or feed opening; therefore, it is difficult to understand how the rate of travel can control combustion. The chain grate may be "designed to burn a large quantity of coal per square foot of surface;" but it is evident that in practice it must fall short of the "design."

There is no call for criticism of the description in connection with Fig. 7, but if a stoker can be made which complete weighs but "about 3500 pounds," and which will give satisfactory work and service, the manufacturer ought to be able to literally take possession of the stoker business, even though it is necessary to slice and clean the fires through small front doors.

There are two other statements in reference to stokers in general in the article which I think erroneous, viz., one in reference to economy in small plants and one in reference to the saving of labor in connection with stokers.

It may be true of some stokers that the utility of mechanical furnaces depends on the labor saving to be effected, but if there be a saving of fuel due to better combustion and less excess air, there will also be a saving due to cleaner heating surface of boiler and both savings will be present in the case of one or two boilers, and the same, relatively, as when a dozen boilers are used. I can show Mr. Hobart numerous small plants where such "a judicious selection of stoker" has been made that in each case the saving in fuel alone, comparing year by year, has been 20 per cent or more. I have one now in mind of three horizontal tubular boilers 66 ins. x 18 ft. with 54 4-in. tubes and rated at 100 horse-power each, where the saving in expense for fuel alone in one year was over $3,000 as compared with the previous year when good hand-fired furnaces with shaking grates were used.

The fact is, the labor saved by use of stokers is overestimated. There is no plant requiring even three firemen where the substitution of stokers will displace even one fireman. But when a judicious selection is made and intelligent operation secured, there will be a saving of fuel cost of 10 to 25 per cent in sections where clean coal (i.e., coal carrying not over 10 per cent of refuse), is used, and in sections where low-grade coals are used the fuel economy will reach 20 to 40 per cent as compared to hand firing, or as compared to an inferior form of mechanical furnace.

It is but just to myself, as well as to Mr. Hobart, that I add that I do not wish to be understood in any criticisms I have made as intending to reflect on Mr. Hobart's integrity or purpose. On the contrary, his article is entitled to respect for merit, and I hope he, as well as others, will pursue the subject.

A NEW TELEPHONE TRANSMITTER.

A new form of telephone transmitter, illustrated by Fig. 1, has been brought out by the Century Telephone Construction Company, of Cleveland, Ohio. This transmitter was shown to the public for the first time at the recent telèphone convention in Cleveland, where it attracted much attention. A special feature is its extreme strength obtained by the use of the heavy cast front, B, and the heavy bridge, C, which holds the electrodes in place, and the heavy pressed outside cup, A. It is asserted that no transmitter using a thin pressed front and back can be made to give uniformly good service, since it is susceptible to vibrations, and the brass stamping for front and back, unless made from heavy material, which is not generally used, is certain to spring and get out of adjustment. A still more important feature is the method employed to prevent "packing" and loss of adjustment. The company has devoted exhaustive experiments to various forms of construction in developing this point. It is stated that when a transmitter packs, it is always at the bottom of the mass of granules, caused by the granules settling; and the packing at the bottom is aggravated in transmitters that have a carbon back with a concave surface, bringing the base of the back electrode closer to the front electrode than the center, and making less resistance at the lower surface through the particles than in the center. The current seeking the path of the least resistance passes principally through the lower portion of the transmitter, causing the granules at the base to bacome overworked, heated, solidified and packed.

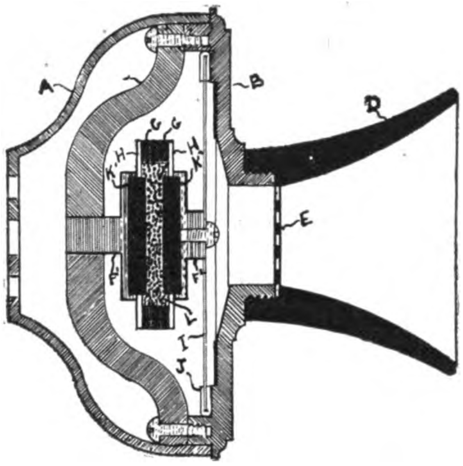


FIG. 1.—CENTURY TELEPHONE TRANSMITTER.

It will be seen by reference to the illustration that the carbon particles fall below the carbon electrodes, K, and rest on the felt cushion, G, and between the two rings of mica, H; also that the two electrodes, K, are absolutely parallel at all points. The theory upon which this construction is based is that the portion of the carbon liable to pack are allowed to drop below the direct line of flow of the electric current, and if there is any solidifying and packing, it occurs ordinarily below the path of the current. Where the circuit begins to pass from one electrode to another, the lower granules will be as loose as in the center or upper portions of the transmitter.

It is claimed, also, that by placing the felt cushion as shown, the uncertain resistance sometimes resulting from the felt cushion coming in contact with the diaphragm is avoided. The carbon electrodes, K, fit closely into the brass cups, F, and are turned to an absolutely true surface. After being fitted into these cups, the back electrode is adjusted to the front one by means of a set screw placed in the brass casing, C. Still another feature is that no metal is used on the faces of the electrodes. The diaphragm is of metal, and is insulated with a rubber ring, J. By taking off the cup, A, the transmitter is entirely open to inspection of all its parts.

THE AMERICAN BRIDGE COMPANY.

The leading manufacturers of bridges and structural iron-work have combined in one huge organization under the style of the American Bridge Company, the specified object of which is the "designing, building and erecting of bridges and all classes of metallic structures," which includes, of course, central station and power-house buildings. The companies that have consolidated are as follows:

American Bridge Works, Chicago, Ill.; Berlin Iron Bridge Company, East Berlin, Conn.; Buffalo Bridge and Iron Works, Buffalo, N. Y.; Carnegie Steel Company (Keystone plant), Pittsburg, Pa.; Edge Moor Bridge Works, Wilmington, Del.; Elmira Bridge Company, Elmira, N. Y.; Gillette-Herzog Manufacturing Company, Minneapolis, Minn.; Groton Bridge and Manufacturing Company, Groton, N. Y.; Hilton Bridge Construction Company, Albany, N. Y.; Horseheads Bridge Company, Horseheads, N. Y.; Lafayette Bridge Company, Lafayette, Ind.; Lassig Bridge and Iron Works, Chicago, Ill.; New Jersey Steel and Iron Company, Trenton, N. J.; New Columbus Bridge Company, Columbus, O.; Pittsburg Bridge Company, Pittsburg, Pa.; A. & P. Roberts Company (Pencoyd Iron Works), Pencoyd, Pa.; Post & McCord, Brooklyn, N. Y.; Rochester Bridge and Iron Works, Rochester, N. Y.; Schultz Bridge and Iron Works, Pittsburg, Pa.; Shiffler Bridge and Iron Company, Pittsburg, Pa.; Union Bridge Company, Athens, Pa.; Milwaukee Bridge Company, Milwaukee, Wis.; Wrought Iron Bridge Company, Canton, O.; Youngstown Bridge Company, Youngstown, O.

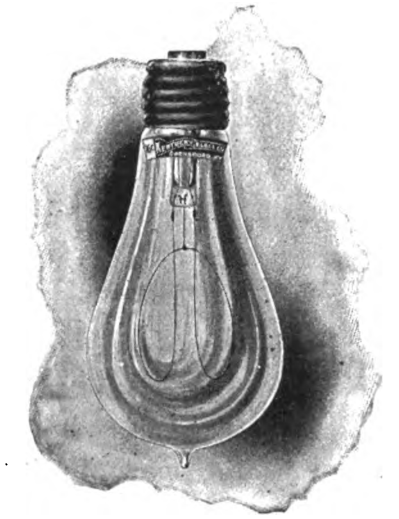


FIG. 2 —KENTUCKY INCANDESCENT LAMP.

The combined capacity of these plants is 600,000 tons per annum. The Pencoyd plant of the A. & P. Roberts Company also comprises one of the best and most complete rolling mills for structural material in existence, with a capacity of 200,000 tons per annum.

The executive organization is made up entirely of men of large practical experience, headed by Mr. Percival Roberts, Jr., one of the leading rolling mill managers of the country. The Pencoyd plant of the A. & P. Roberts Company, which is the most complete bridge and structural plant in the world, has been developed under his personal supervision and is the result of his energy and ability.

KENTUCKY INCANDESCENT LAMP.

Figs. 2 and 3 represent two styles of incandescent lamp manufactured by the Kentucky Electrical Company, of Owensboro, Ky. While the illustrations do not indicate any difference between the Kentucky lamp and the product of older makers, there are several features claimed for this lamp which invite attention. The makers state that a peculiar process is employed which gives a hard, dense filament and one that maintains its candle-power and efficiency throughout the normal life, and without blackening the globe. This unusual combination of results is said to have been thoroughly demonstrated by an exhaustive test. In one case, it is stated, a bank of 104-volt lamps after burning 1200 hours tested up to full candle-power at 105 volts—an obviously remarkable result. The lamps are individually exhausted, giving a uniform vacuum in all of them; they are made in the usual candle-powers and efficiencies, and for all standard voltages. The bulbs are of the well-known Libbey glass.

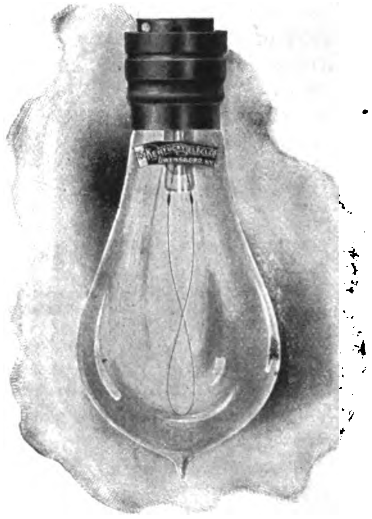


FIG. 3.—KENTUCKY INCANDESCENT LAMP.

New Apparatus and Appliances

BERNARD ENCLOSED MULTIPOLAR MOTOR.

Fig. 1 represents the latest type of enclosed multipolar machine with exposed commutator, manufactured by the E. G. Bernard Company, Troy, N. Y. Fig. 1 shows the machine in its ventilated form, and Fig. 2 the same machine entirely enclosed. These machines, which are fitted with reaction brush holders and self-oiling bearings, are adjustable to any position, and can be mounted direct to line shaft on the ceiling or side wall. The commutator and brushes are designed for a maximum current density of 25 amperes per square inch at the brush contact, thus insuring a cool commutator with carbon brushes. The motors have been designed also in accordance with the latest United States Government specifications. The bearings are self-oiling and furnished with bronze oil rings or bicycle chains. Mica insulation is used throughout. The motors are normally furnished in the ventilated form, but are also made wholly enclosed principally for use in mines and damp places. The form of construction admits of ready adaptation for connection either by belts, gears or direct attachment to lathes, planers, rolls, presses, house water pumps, fans, elevators, etc. The motors are built in sizes from ½ to 35 horse-power and designed for speeds varying from 150 r.p.m. in the largest size to 1700 r.p.m. in the smallest size.

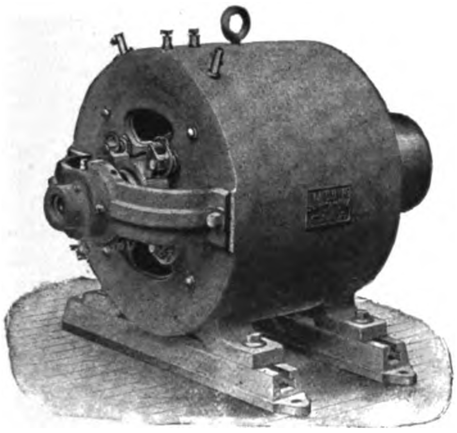


FIG. 1.—BERNARD VENTILATED MOTOR.

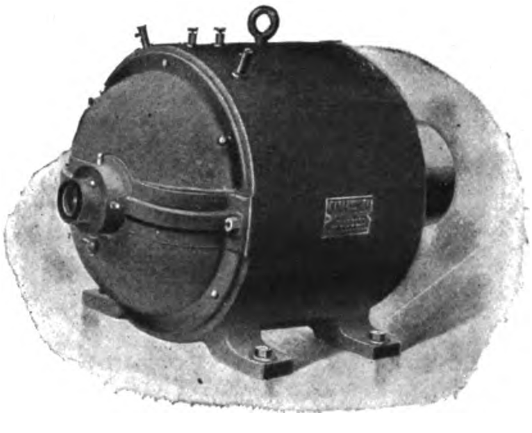


FIG. 2.—BERNARD ENCLOSED MOTOR.

CLAYTON & LAMBERT GASOLINE TORCH.

Fig. 3 represents gasoline torch No. 1, made by the Clayton & Lambert Manufacturing Company of Detroit, Mich. The burner hangs on a swivel joint and can be pointed in any direction and has large clean-cut openings which enable the user to keep it in good order. Particular attention is called to the needle, which is fitted with a stuffing-box that may be tightened when necessary. The mounts are double shouldered and fitted with a taper leading to the first shoulder, which sets back on the needle so that the seat is in the center of the large body of metal, and therefore does not enlarge the orifice or opening through which the gasoline passes, which would soon ruin the burner. If after years of use the orifice is enlarged, a few blows with a hammer on the side near the opening will close the metal on itself. A quick-opening thread is used on the needle. The torch is well balanced and may be turned so that the flame is pointed where desired without any strain on the hand or wrist. It is constructed so that the user holds it in his left hand, leaving the right hand free. The flame being at the side of the tank and free from smoke, the operator is enable to see the work. The flame is blue and free from smoke, and under perfect control of the user, so that a soft flame for use on light work, or a more intense one for heavy work may be had at will. The tanks are drawn out of heavy brass, free from seams, with heavy raised bottoms. A brass air pump constitutes the latest improvement; it screws into the tank, thus protecting it from heat or acident, and can be easily unscrewed in case repairs are needed.

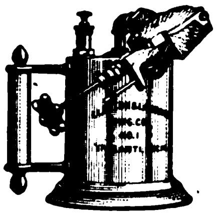


FIG. 3.—GASOLINE TORCH.

MERRILL'S AUTOMATIC LUBRICATOR.

The lubricator shown by Fig. 4 is intended to be attached to any reciprocating or oscillating part of an engine or other machine requiring constant and reliable lubrication. As it feeds grease instead of oil, it may be attached in any position desired. It feeds only when the part to which it is attached is in motion, and no feeding or loss can occur after the motion ceases. The base of the lubricator is screwed firmly into the part to be lubricated in the usual way. The body is attached to the base by the union nut or enlarged ring at the bottom. When this is unscrewed the entire upper part comes off; the barrel is filled with a charge of grease and returned and securely clamped in the position again by the union nut. The feeding is accomplished by the pressure of a piston, and this pressure is applied by the oscillations of the pendulum seen in the front. By the adjustment of the stop screws at the side, the pawl attached to the pendulum may be made to take from one to six or more teeth of the ratchet wheel for each oscillation. On the ratchet wheel shaft is a worm which meshes into the large worm wheel at the top; the central screw or spindle is splined and revolves with this wheel, at the same time traveling downward by the operation of its thread in the central nut, which is screwed into the bracket or guide at the top. The feeding goes on as long as the oscillations continue, until the piston reaches the bottom and the grease is all expelled. To raise the piston for refilling the barrel, the central nut, which has a milled and notched head, is unscrewed from the bracket, the piston is pulled up, the nut is twirled down the screw by hand and screwed tight in its place again. The ratchet wheel may be pulled around by hand, until the slack is taken up and the feed is fully established, and if at any time it is desirable to feed in an extra quantity of grease, this also may be done by turning the ratchet wheel. The lubricator may be made of any size and for any rate of feed desired. The one here shown will hold about 14 cubic inches or somewhat less than a half-pint of grease. The ratchet wheel has 100 teeth, the spindle wheel has 125 teeth, the central spindle has 24 threads to the inch and the total travel of the piston is 3½ inches. If, then, the pendulum is set to take two teeth of the ratchet wheel for each stroke, the number of strokes required to empty the barrel will be: $100 \div 2 \times 125 \times 24 \times 3.5 = 525{,}000$, and at 200 strokes a minute one charge would last 2,625 minutes, or, say, 45 hours. Any of the usual kinds of grease may be used in the lubricator, and any percentage of pure graphite may be mixed with it. The worm is of steel, the pawls are of hardened steel and the wheels

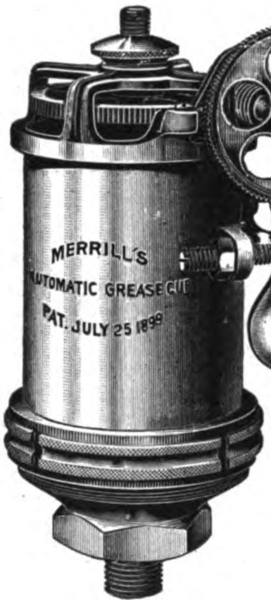


FIG. 4.—MERRILL'S AUTOMATIC-FEED LUBRICATOR.

are of hard bronze. The lubricator is made and sold by Jas. L. Robertson & Sons, New York.

THE WEINLAND TUBE CLEANER.

The accompanying illustration, Fig. 5, represents the practical application of the Weiland tube cleaner, built by the Lagonda Manufacturing Company, of Springfield, O. This cut shows very plainly how the machine is held in place while the work is being done, and also shows the extremely simple manner of attaching the cleaner and changing it from tube to tube or from one row of tubes to another. The machine itself is driven by either an electric motor, steam engine or any other source of power, and the manufacturers recommend the use of about 5 horse-power, although they have driven the machine sucessfully with a 3-h.p. motor. In preparing for its use it is only necessary to open the doors and remove the caps from the tubes, just as is required with any other cleaner. A platform is built in front of the boiler on which the operator stands. To the cleaner is attached a swinging board with flanged pulleys attached to the bottom of it, over which the belt runs. This board swings perfectly free and the bottom of it can be drawn so that the belt is tightened for driving when the machine is in position, and loosened again when desiring to change from one tube to another. One man can readily handle the apparatus, and it is stated that the time saved in getting ready to clean boilers is as much almost as is required in cleaning with some other devices. A series of cleaner heads are used, by means of which the scale can be quickly and thoroughly removed from any tube.

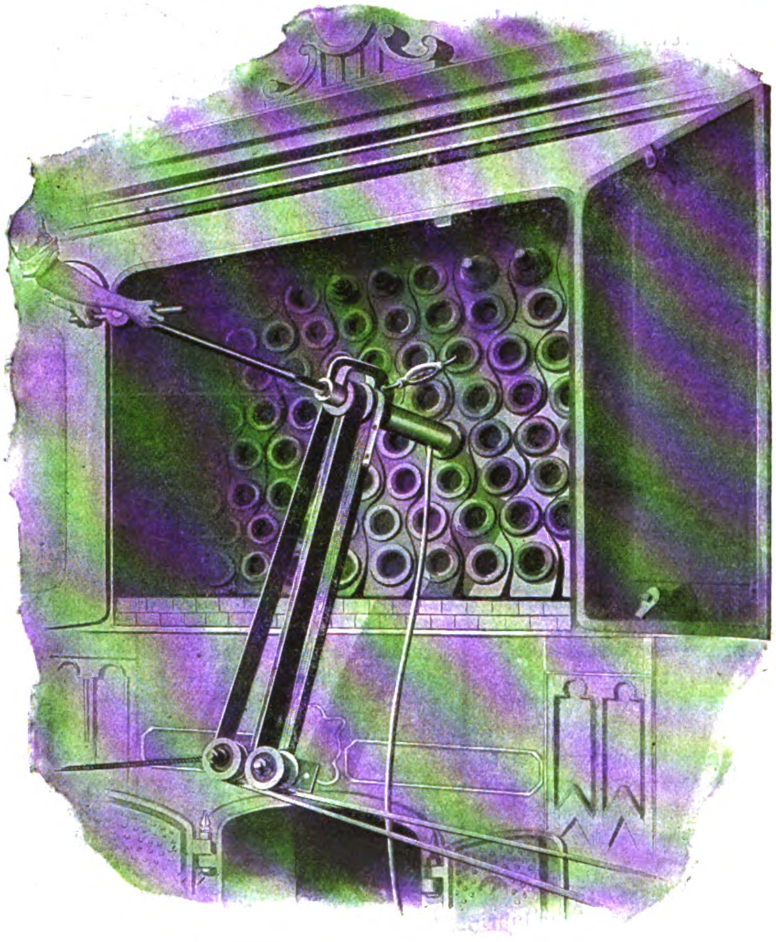


FIG. 5.—WEINLAND TUBE CLEANER IN OPERATION.

AMERICAN ELECTRICAL SPECIALTIES.

The American Electric Fuse Company, of Chicago, manufactures a full line of telegraph and telephone fuse-blocks, one of which is shown by Fig. 6. This device, which is known as Lightning Arrester No. 69, is a combined arrester and fuse block, the carbon blocks at the right-hand end comprising the lightning arrester and Maxstadt fuse links being employed to connect the line terminals. As the engraving plainly indicates, the fuses are separated by a porcelain wall and covered by a sheet of mica held in place by a flat spring.

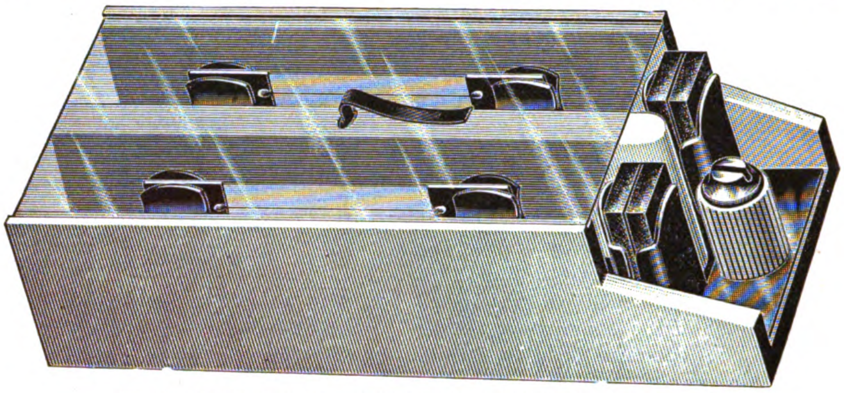


FIG. 6.—COMBINED FUSE BLOCK AND LIGHTNING ARRESTER.

The American Company also manufactures the wire connector shown by Fig. 7, for use in splicing telegraph and telephone wires. This connector is made in all standard sizes.

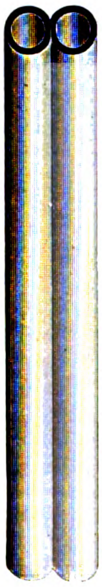


FIG. 7.

INTERCOMMUNICATING TELEPHONE OUTFIT.

Thomas, Wilcox & Dietz, of Cleveland, O., are making a specialty of the telephone outfit illustrated by Fig. 8, which comprises a long-distance granular carbon transmitter, double-pole receiver, improved hook switch, dial selective switch, induction coil, battery and vibrating call bell. The selective switch lever is firmly adjusted by means of a lock nut, so that the contact is always reliable. The hook switch is of a new form and makes liberal wiping contacts with the springs. The induction coil is located within the battery box beneath the shelf, and the latter, together with the back-board, are of nicely finished quartered oak. The selective switch (at the top of the back-board), push-button cap, bell and transmitter cap are heavily nickel-plated. The outfit here shown is adapted for use on intercommunicating systems of three to fifteen stations, and is one of the most attractive of the line of instruments made by the above-named firm.

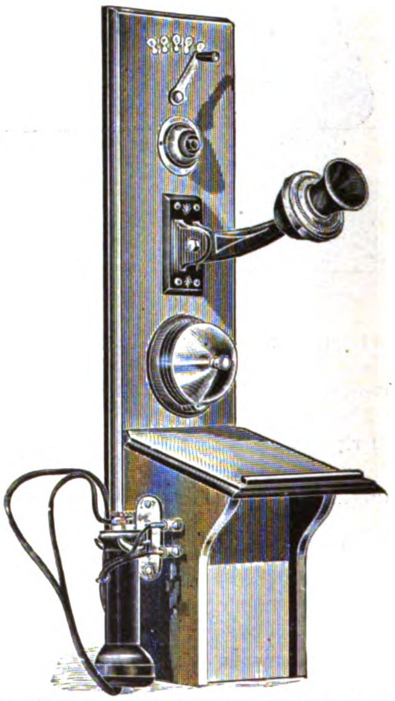


FIG. 8.– INTERCOMMUNICATING TELEPHONE.

American Electrician.

Vol XII. New York, September, 1900. No. 9

A FORTY-MILE INTERURBAN ELECTRIC RAILWAY.

POWER STATION AND EQUIPMENT OF THE D., S. & U. ELECTRIC RAILWAY.

BY W. N. ZURFLUH.

There has been completed recently an interurban electric railway connecting the cities of Dayton, Springfield and Urbana (Ohio), a distance of forty miles. The building of this road has been contemplated for some time, and active operations were begun last summer, when the division from Dayton to Springfield was started. The company has sought to own its right of way, and does so with the exception of sections where the line passes through towns and cities. The Dayton end of the line starts at the corner of Third and Main streets, and the local street railway tracks are used. After leaving the city of Dayton the line passes through a most picturesque country in the Mad River Valley.

The track parallels the Dayton branches of the Erie and the Big Four Railroads, and just outside of Dayton it is carried on a trestle over the tracks of these companies. The road passes through some of the richest farming country in the state of Ohio; also through the towns of Osborn and Medway, and also extends to Tecumseh Park, a summer resort, which is to be run in connection with the road.

The power house is located at Medway, 9 miles west of Springfield, on the bank of the Mad River. Fig. 4 is a view in the engine room, taken just before the installation was completed, and Fig. 5 is a view in the boiler room. Fig. 1 is a view taken just after the plant was started up. The building is of brick, with stone foundations and gray sandstone trimmings. The main entrance is through 7-ft. double doors, which lead into the engine and dynamo room. At each side and to the rear of this room are 10-ft. doors. The engine and dynamo foundations are brought up to the level of the floor. At the extreme south end a water motor is to be placed, and used as an auxiliary power. The site of the plant was formerly occupied by a water-power mill and the water is still available.

A stairway leads from the engine room down into the boiler room, the floor of the latter being ten feet lower than the engine room floor. The roof is supported by iron trusses; on the top of each truss a 2-in. nailing strip is bolted. To this strip the roof planking is spiked. The roof purlins are of hard pine 4 ins. x 6 ins. The engine room roof is covered with iron shingles, and is painted with two coats

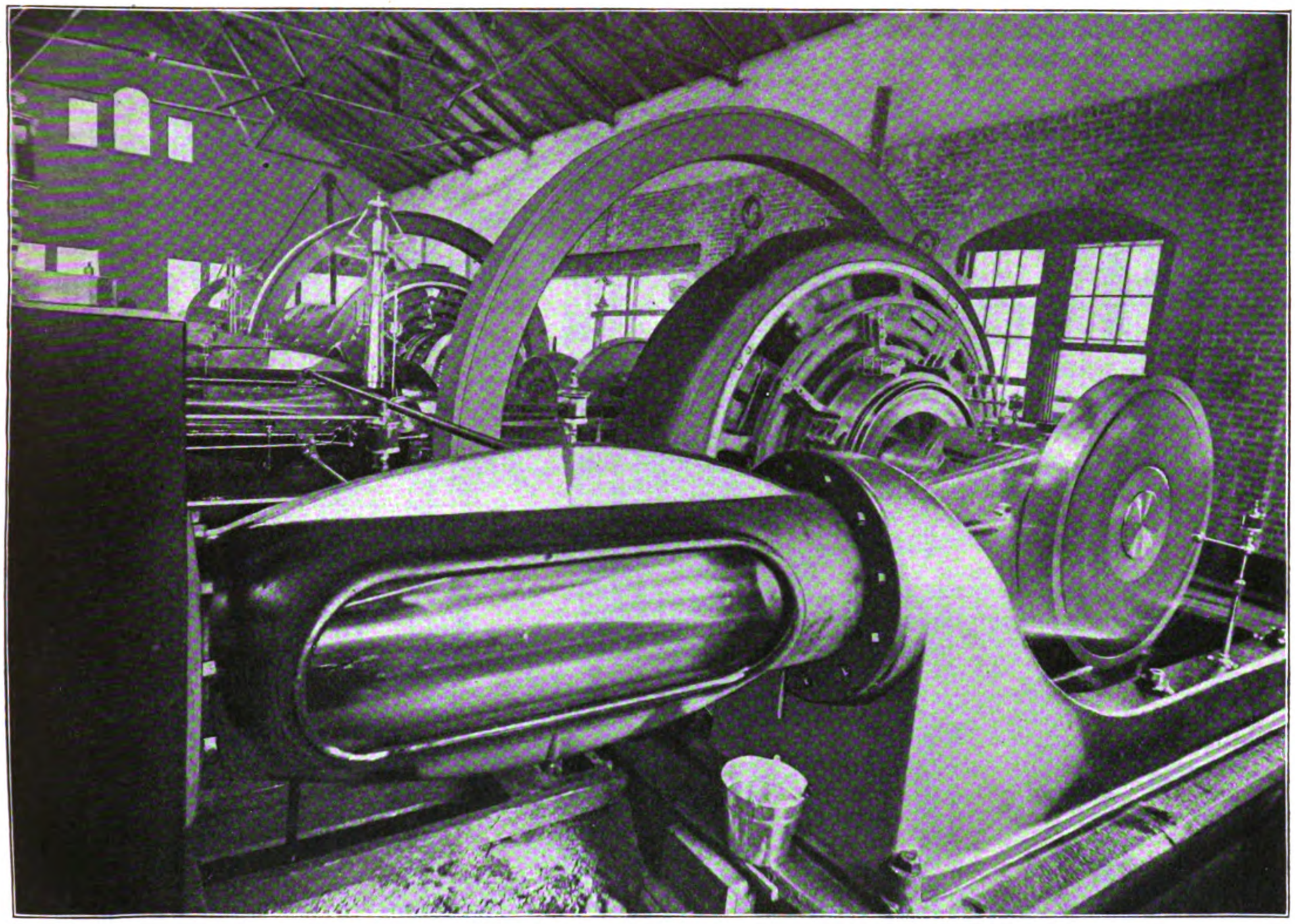


FIG. 1.—VIEW IN A CORNER OF THE GENERATOR ROOM.

of lead and oil. The roofing over the boiler room is five-ply roofing felt covered with a heavy coating of tar, pitch and gravel. The chimney is a brick structure located, as shown in Fig. 2, at the rear of the engine room and south of the boiler room. It is circular in shape, with a base 14 ft. in diameter. The boiler plant consists of three Babcock & Wilcox water-tube boilers, which will develop 851 horse-power; this is to be increased later. The live steam pipe from each boiler is 8-ins.; the three pipes discharge into a 12-in. header at the rear of the boilers, from which each pair of engines receives steam through a 6-in. pipe and a separat-

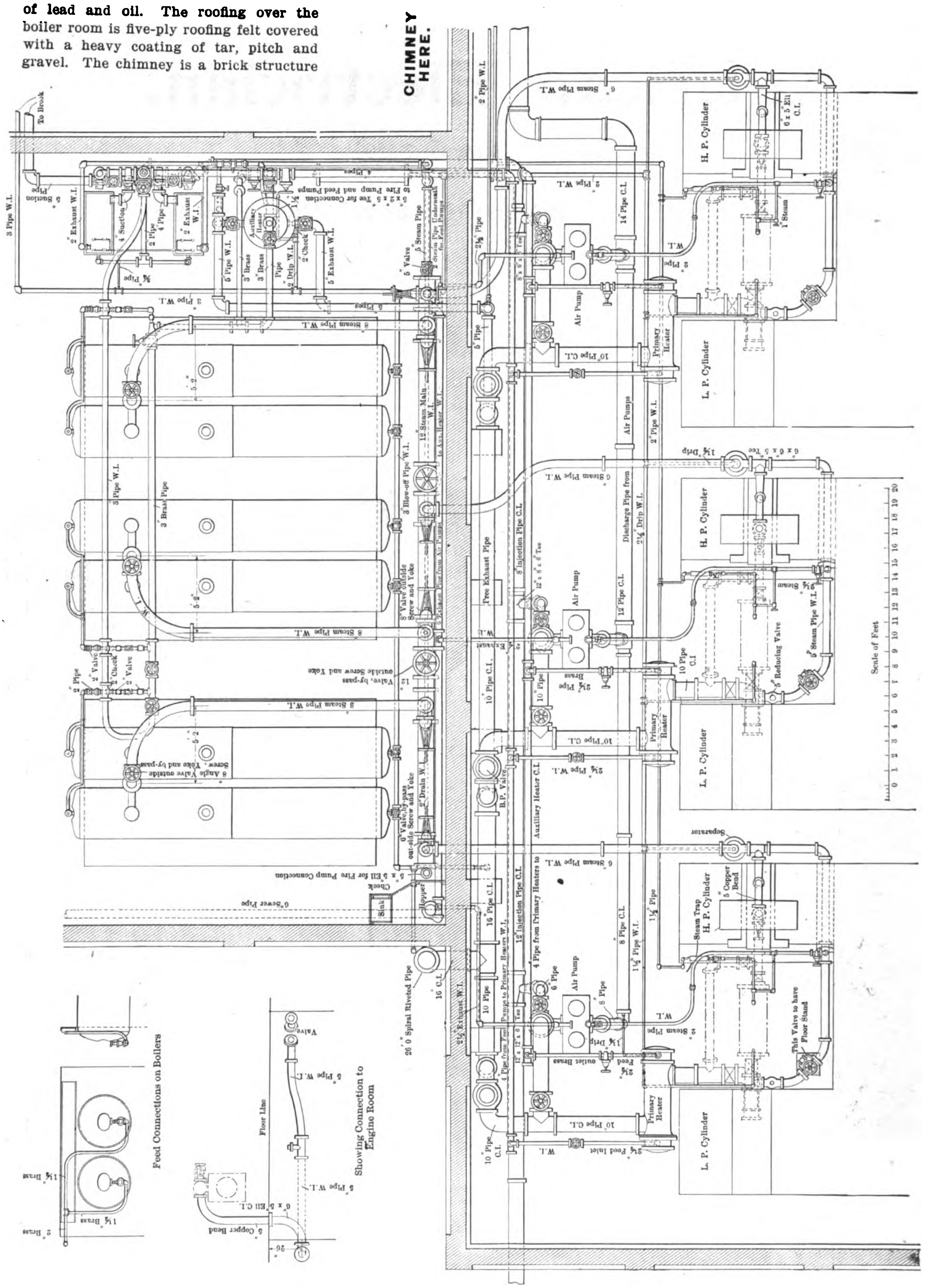

CHIMNEY HERE.
To Brook
3 Pipe W.I.
H. P. Cylinder
L. P. Cylinder
Air Pump
Primary Heater
Air Pumps
12 Steam Main W.I.
Free Exhaust Pipe
Scale of Feet
Feed Connections on Boilers
Showing Connection to Engine Room
Floor Line
Separator
Steam Trap
Reducing Valve
This Valve to have Floor Stand
Sink
Hopper
Check
6 Sewer Pipe
26 0 Spiral Riveted Pipe
16 C.I.

FIG. 2.—PLAN OF THE STEAM PLANT, SHOWING THE DETAILS OF THE STEAM AND WATER PIPING.

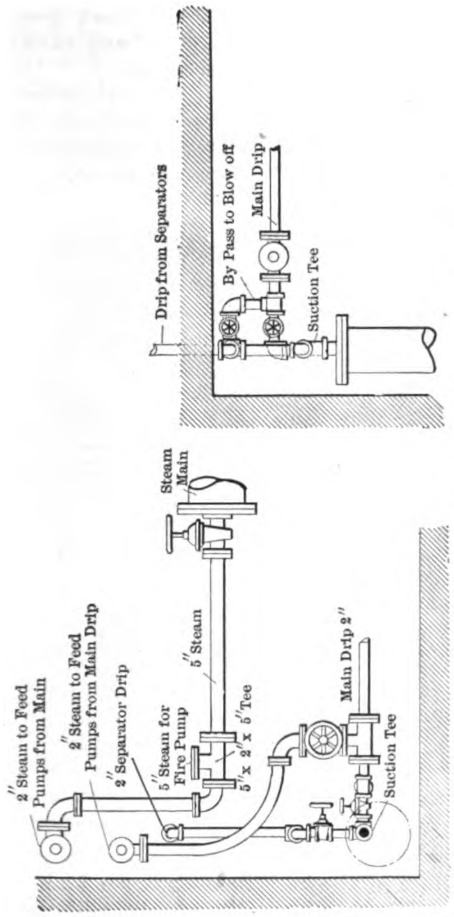

Drip from Separators
By Pass to Blow off
Main Drip
Suction Tee
2" Steam to Feed Pumps from Main
2" Steam to Feed Pumps from Main Drip
2" Separator Drip
5" Steam for Fire Pump
5" Steam
5" x 2" x 5" Tee
Steam Main
Main Drip 2"
Suction Tee

FIG. 3A.—SOME DETAILS OF THE PUMP PIPING AND DRIPS.

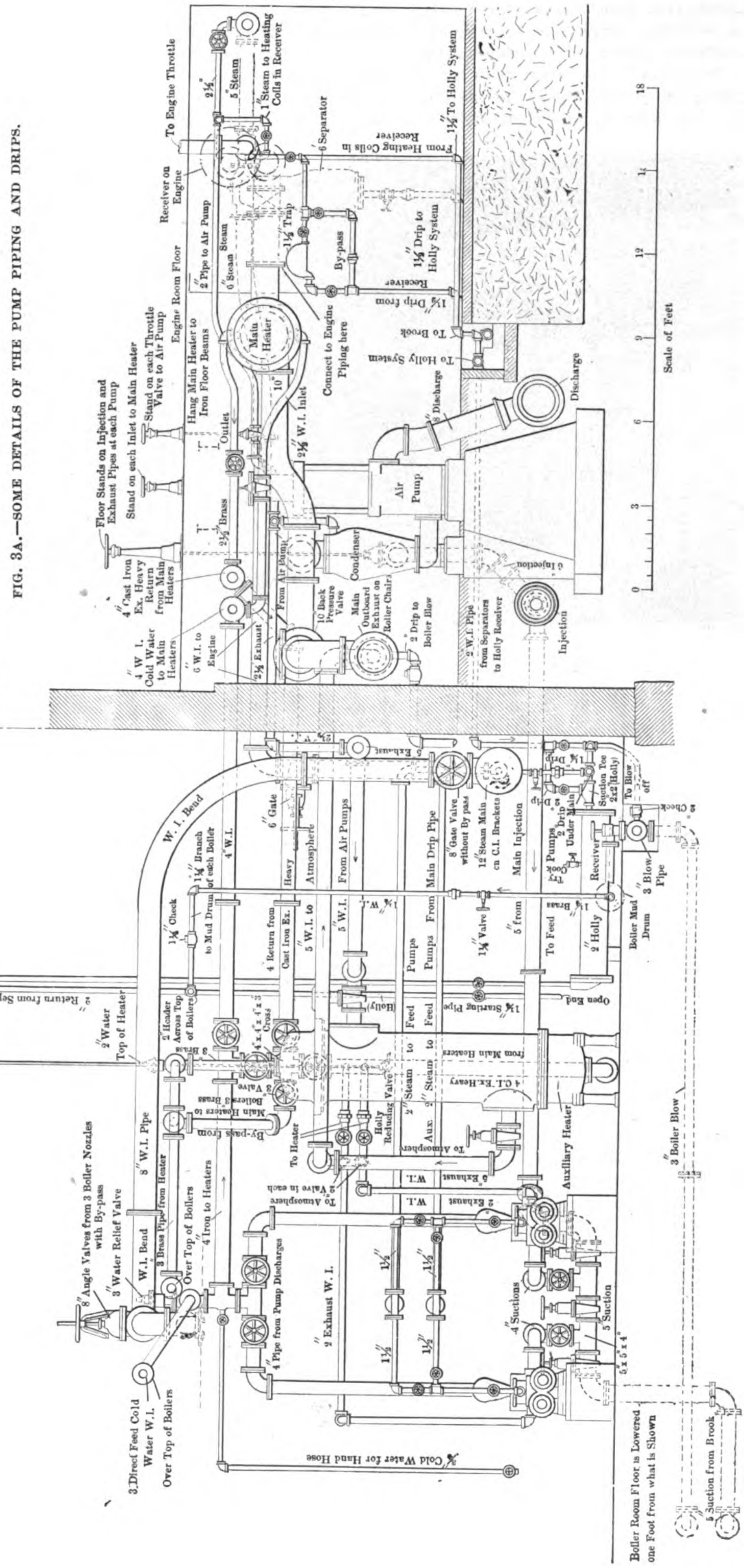

To Engine Throttle
5" Steam
1" Steam to Heating Coils in Receiver
6" Separator
From Heating Coils in Receiver
1½" To Holly System
1½" Trap
By-pass
1½" Drip to Holly System
1¼" Drip from Receiver
To Brook
To Holly System
Receiver on Engine
2" Pipe to Air Pump
6" Steam
Engine Room Floor
Main Heater
Connect to Engine Piping here
Hang Main Heater to Iron Floor Beams
Stand on each Throttle Valve to Air Pump
Stand on each Inlet to Main Heater
Floor Stands on Injection and Exhaust Pipes at each Pump
Outlet
10"
2½" W. I. Inlet
8" Discharge
Discharge
Air Pump
2½" Brass
Condenser
6" Injection
Injection
4" Cast Iron Ex. Heavy Return from Main Heaters
From Air Pump
10" Back Pressure Valve
Main Outboard Exhaust on Roller Chairs
2" Drip to Boiler Blow
2" W. I. Pipe from Separators to Holly Receiver
4" W. I. Cold Water to Main Heaters
6" W. I. to Engine
2½" Exhaust
Scale of Feet
0 3 6 9 12 15 18
W. I. Bend
6" Gate
1¼" Branch of each Boiler
4" W. I.
1¼" Check
to Mud Drum
4" Return from Cast Iron Ex. Heavy
5" W. I. to Atmosphere
5" W. I. From Air Pumps
Pumps From Main Drip Pipe
8" Gate Valve without By pass
12" Steam Main on C. I. Brackets
Main Injection
1¼" Valve
5" from
To Feed Pumps
Receiver
Boiler Mud Drum
2" Holly
3" Blow Pipe
To Blow off
Suction Tee
Open End
1¼" Starting Pipe
2" Return from Separator
2" Water Top of Heater
2" Header Across Top of Boilers
3" Brass
from Main Heaters
4 C. I. Ex. Heavy
Holly Reducing Valve
2" Steam to Feed Pumps
2" Steam Aux.
To Atmosphere
To Heater
By-pass from Main Heaters to Boilers
5" Exhaust W. I.
2" Exhaust W. I.
2" Valve in each To Atmosphere
Auxiliary Heater
3" Boiler Blow
8" W. I. Pipe
8" Brass Pipe from Heater
4" Iron to Heaters
Over Top of Boilers
W. I. Bend
3" Water Relief Valve
8" Angle Valves from 3 Boiler Nozzles with By-pass
4" Pipe from Pump Discharges
2" Exhaust W. I.
4" Suctions
5" Suction
5 x 5 x 4
3" Direct Feed Cold Water W. I. Over Top of Boilers
¾" Cold Water for Hand Hose
Boiler Room Floor is Lowered one Foot from what is Shown
5" Suction from Brook
Separator for 2" Holly Gravity Return System Located Outside of the End of the Roof Monitor in a Weather Proof Housing Accessible from the Roof by a Weather Proof Door
1¼" Riser from Receiver
½" To Reducing Valve and Heater
Lead Back to Wall

FIG. 3.—ELEVATION OF THE STEAM AND WATER PIPING.

or. The pumps receive steam through a 3-in. pipe and have a 5-in. suction pipe to the river. All the piping is extra heavy. Fig. 2 is a plan view showing the whole piping lay-out, and Fig. 3 is the corresponding elevation. It will be noticed that the engines are arranged to exhaust through individual primary heaters and thence either to the individual jet condensers or to air, in the usual manner. There is an auxiliary heater, as shown in both diagrams, located in the boiler room, through which the exhausts from all of the auxiliaries pass. The feed water passes from the primary heaters through the auxiliary heater on its way to the boiler feed main. The other features of the piping are clearly shown by the diagrams. Fig. 6 shows the form of roller suspension employed for the large piping everywhere except near the partition wall, where roller chairs or brackets are used, bolted to the wall. There are two Blake duplex pumps for boiler feeding and three Blake jet condensers and air pumps.

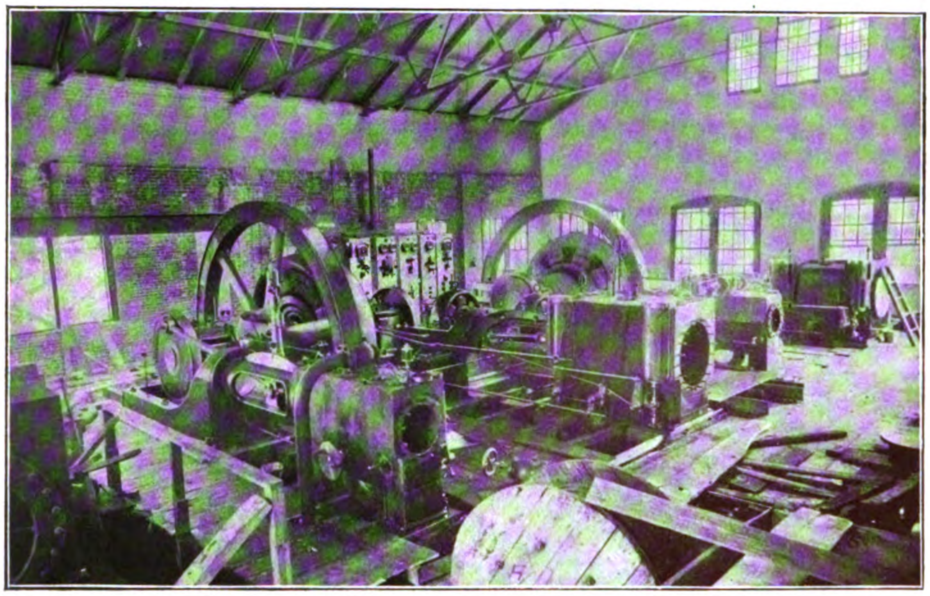


FIG. 4.—ENGINE ROOM DURING PROCESS OF INSTALLATION.

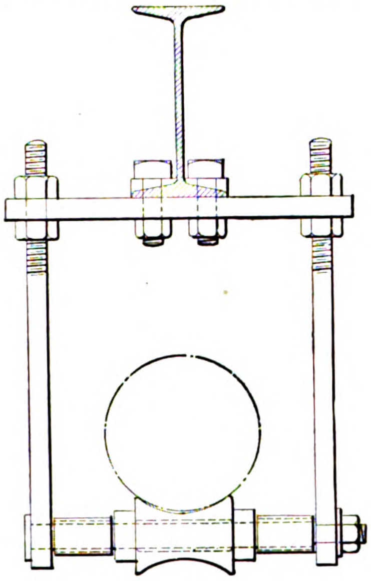


FIG. 6.—PIPE HANGER.

The engine plant comprises three cross-compound Slater-Corliss engines, with cylinders 16 ins. and 32 ins. in diameter, respectively, and 42 ins. stroke. With 125 lbs. steam pressure these engines drive the generators, to which they are directly connected, at 100 r.p.m. The cylinders are made with an exhaust chamber separated by an air space from the cylinder barrel.

The Slater automatic valve gear is used and the governor is of the same make, of the weighted type, and operates both the high-pressure and the low-pressure cylinder valve gears. The steam and exhaust valves on the low-pressure cylinders are driven by separate eccentrics. The main journals are 13 ins. in diameter and 22 ins. long; they are lined with babbitt metal. The crank shafts are 15 ins. in diameter, except in the bearings, and each engine has a 15-ft. 15-ton balance wheel, with a 12-in. rim. The cranks are of the counterbalanced disc type, and the crank-pins are 5 ins. long and 5 ins. in diameter. The engines will develop 450 horse-power each. The exhaust steam from each engine passes into a 9 x 20 x 12-in. Blake condenser, which has a 14-in. discharge pipe.

The foundations of the engines are brick masonry laid on 4 ft. of concrete, and are carried up 10 ft. to the level of the engine floor.

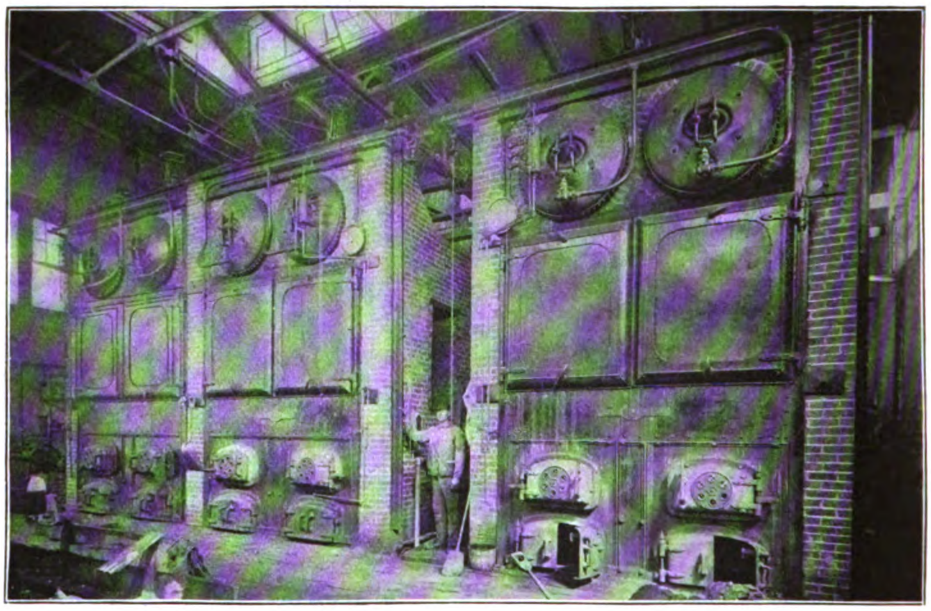


FIG. 5.—A VIEW IN THE BOILER ROOM.

Connected directly to the engine shafts are three Westinghouse 8-pole generators of 542 amperes and 600 volts output, compounded for 10 per cent rise in e.m.f. These machines are of the standard Westinghouse design and are too well known to require further description.

The boosters are driven by 500-volt motors which take their current from the main bus-bars. The booster dynamos are 6-pole machines, generating 250 volts at 675 r.p.m.

Fig. 7 is a diagram of the booster circuits; this arrangement is rather special. The circuit-breaker which protects the motor armature is arranged to open the feeder which the booster is serving, as well as the motor circuit, in case of trouble in the latter. The object of this is to prevent the series-wound dynamos from reversing and running away, as it would do if the motor circuit were opened and the feeder remained closed. The method of connecting up the circuit-breaker affords protection in this particular case, but besides this are provided an auxiliary tripping coil on the circuit-breaker and special connections on the starting box of the booster motor. The cross-bar of the starting box, in the normal running position, is on the buttons, R R, connecting the motor armature to the bus-bars. Should the double-pole switch be opened to shut down the booster motor while the booster is running, the starting box lever is released by its magnet and flies around to the buttons, S, S, completing the circuit through the auxiliary tripping coil and throwing the circuit-breaker, so as to prevent "motoring" by the booster dynamo, which would otherwise have been left in circuit and free to run away. Reference to Fig. 8 will help to an understanding of the starting-box construction.

At present the switchboard comprises five white marble panels, 2 ft. wide and 7 ft. high, as shown in Fig. 8. At the extreme left is the main generator panel, which has on it a latest pattern Weston voltmeter, reading to 600 volts; a 1200-ampere Weston ammeter, one 1200-ampere Westinghouse circuit-breaker; two 1200 ampere single-throw, single-pole Westinghouse switches and the generator rheostat.

Next to the right is the feeder panel which has on it one round type Westinghouse ammeter, reading to 600 amperes; one Westinghouse voltmeter reading to 600 volts; a pilot lamp; two circuit-breakers of 600 amperes capacity, and two single-throw single-pole switches. Between the circuit-breakers a marble slab 18 ins. long and 9 ins. wide is placed to prevent flashing over. The third panel is for the booster dynamo and has on it a 300-ampere round pattern Westinghouse ammeter; a 300-volt voltmeter of the same make; a 300-ampere circuit-breaker; main switch and rheostat. Next to this is the booster motor panel, having on it a 600-ampere ammeter; a circuit-breaker; single-pole main switch and at the bottom the starting box previously mentioned. The last panel is a second generator panel. The main line connections at present are only temporary. They lead out from the feeder panel to the trolley wire, a distance of about 500 ft.

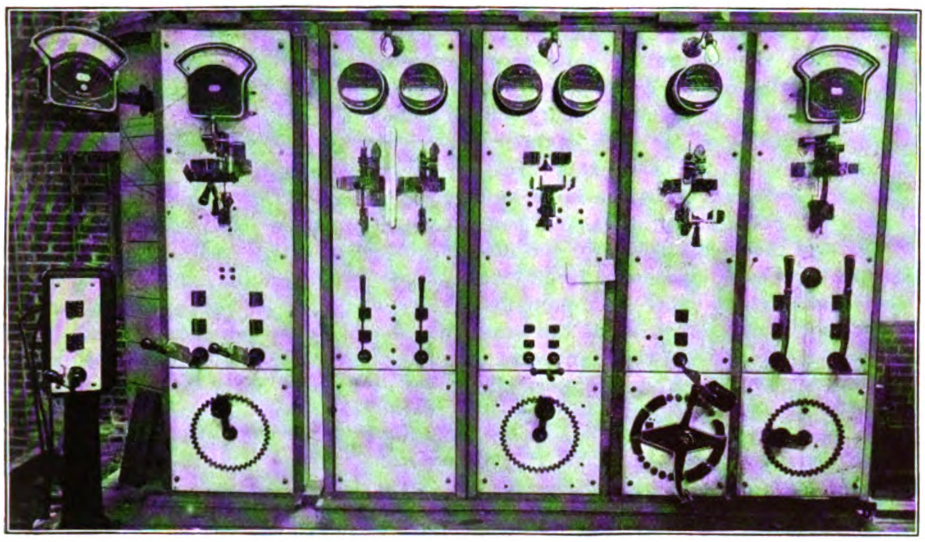


FIG. 8.—THE SWITCHBOARD.

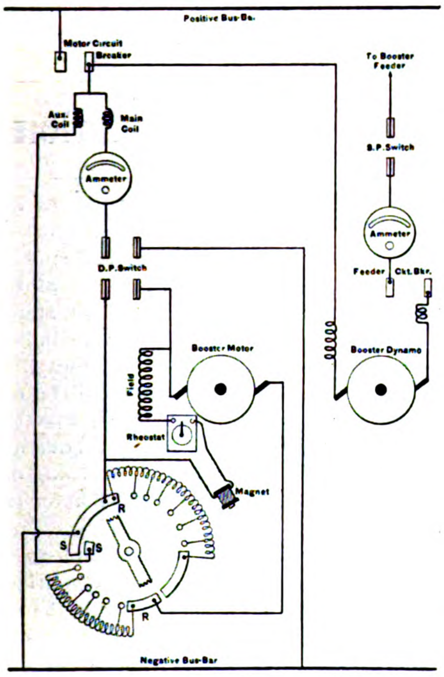


FIG. 7.—BOOSTER CONNECTIONS.

The roadbed is well ballasted with gravel and cinders and the rails are 70 lbs. per yard. The trolley wire is No. 0000, and in the country is supported by iron brackets 7 ft. long, fastened to 25-ft. cedar poles. General Electric trolley supports and fixtures are used. In the cities the cross suspension system is used, the trolley being suspended from the poles by galvanized iron strand attached to screw eyes, the shanks of which pass through holes bored through the poles and are drawn up by nuts and washers. Glass insulators are inserted in the suspension cables. The feeders and booster wires, when erected, are to feed the line about seven miles each way from the station.

The cars are very large, being 50 ft. long and 8½ ft. wide, and at one end of each car there is a smoking compartment. The car equipment comprises four 50-h. p. Westinghouse motors of the latest type, and built to sustain a heavy overload. The cars have two trolleys, one at each end, and are all vestibuled. They were built at the Barney & Smith car shops at Dayton. Fig. 9 shows one of the cars.

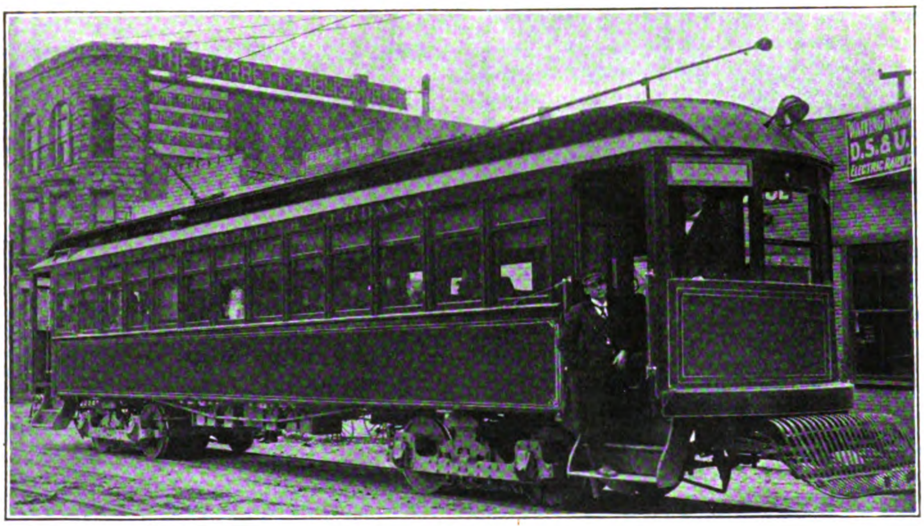


FIG. 9.—ONE OF THE REGULAR CARS.

It is the intention of the company to erect several more power houses along the line as the road is extended, and it is expected that the road will do most of the local passenger and express business between the cities along its route. It also proposes to carry the United States mail. Although the road has been in operation a very short time it is already doing an enormous business. The general manager of the D., S. & U. R. R. is Mr. Fred J. Green; the chief engineer at the power house is Mr. D. H. Ullery, and the assistant engineer Mr. Clarence Dinnon, to all of whom the writer is indebted for many courtesies. Acknowledgment is also due to Messrs. Sheaff & Jaasted, Boston, for data relating to the steam plant, which was installed under their supervision.

STEAM EQUIPMENT FOR SMALL CENTRAL STATIONS.

BY L B MATHER.

Where condensing water is available without cost it is almost axiomatic that condensing pays even in the smallest of stations, down to a point where coal is so cheap that the saving does not pay interest and depreciation charges on the extra cost of the condensing equipment. Although this statement sounds simple, the application of the principle involved is not always easy. In the first place one cannot base one's figures on the rated output of the equipment in small plants, because the engines run at full load during only a small proportion of each twenty-four hours, or twelve hours, or whatever the daily run may be. Hence, it becomes necessary, in order to compare condensing and non-condensing costs, to know approximately how the daily work will average up. If some fair estimate of this can be arrived at, then an intelligent decision can be made as to the approximate saving obtainable by condensing and, consequently, the advisability of it. Where a station is of such a size, say 500 kilowatts output, as to enable one to run the generating plant at or near full load on the units in use, then coal must be obtainable at charity figures in order to justify non-condensing operation.

This naturally leads to the question of the division of the generating plant. In no case should a plant contain only a single unit. If it be of such small magnitude even as 50 kilowatts, there should be two engines of 40 to 50 horse-power ability each. It is a peculiar fact, but one that the writer has repeatedly noticed, that an odd number of units seems to give greatest flexibility in plants of moderate size. A 600-h.p. plant, for example, will preferably contain three 200-h.p. engines; four engines of 150-h.p. each or two of 300-h.p. each will not be nearly so desirable. It seems scarcely necessary to say that the generating units, even in the smallest of plants, should all be of one size, for any one class of service. The argument that a small unit is economical for handling the small-load period of the day's run is a plausible but specious one. The smallest load on an average station of 200 kilowatts full-load output will be about 25 to 30 kilowatts—say 40 horse-power at the engine. The largest source of inefficiency at that load will be the boiler and piping, and this will not be helped by running a 40-h.p. or 50-h.p. generating unit instead of one of 100 horse-power, which would be available if a plant of three 100-h.p. units were provided to take care of the 200 kilowatts output (with a small margin). Moreover, it is extremely doubtful if the difference in the steam consumption would justify the disadvantage of the two sizes of generating equipment. The tremendous advantage of having all parts and machines interchangeable outweighs a saving of several tons of coal a year.

In the foregoing paragraphs the figures representing station output or size refer to the total generating ability and not to the maximum load. It should not be necessary to point out that the maximum ability of a steam plant should always exceed considerably the maximum load. If the station supplies current for traction purposes, it will seldom be found advisable to put in any equipment smaller than a 200-h.p. engine, of which there should be not less than two at the outset. As soon as the output of the station increases to such an extent that during the heavy-load period the second generating unit must be operated, a third equipment should be installed, so that the plant will always have a reserve generating equipment. In the case of a railway plant where there is not much prospect for any considerable increase in the service, it will be found good practice to make the generating units of an output equal to one-half the maximum load and to provide three of these units.

If the station supplies a lighting service and storage batteries are not employed in conjunction with the generators, the maximum load should usually not be allowed to exceed about 80 per cent of the maximum ability of the plant before additional equipment is put in. Where the service gives definite promise of continued enlargement, an additional generating unit should be installed when the maximum load reaches a value equal to about three-quarters of the maximum output ability of the existing plant. If, on the other hand, there is not much prospect for further increase in the output of the station, it will doubtless be better, from a business viewpoint, to wait until the maximum load about equals the maximum efficient ability of the generating plant before adding to the equipment.

If the plant runs condensing and gives a twenty-four-hour service, the total condensing equipment may be advisedly divided into two units of equal size, up to a point where the generating units are of fairly large size, say 250 horse-power each, when individual condensing equipments should be used—one for each engine. It is not within the scope of this article, however, to discuss plants so large as to require 250 horse-power units. Of boiler feed pumps there should be two—no more and no less—each capable of feeding the whole boiler plant under maximum load. These would preferably be of the crank and flywheel type from the standpoint of economy, but if the pay-roll does not include an intelligent engineer who appreciates the needs of good machinery, the more easily maintained direct-acting steam pump will do better. No matter which type is used, it is unnecessary refinement to split up the pumping plant into several small units of villainous efficiency. Two pumps exactly alike, each of full-load ability, will give best results.

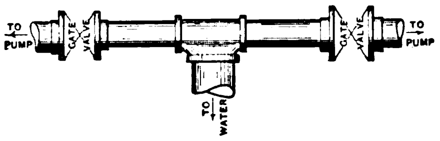


FIG. 1.

There is little to be said concerning the boilers for very small plants. It is self-evident that there should not be less than two, and if the maximum output of the plant be under 300 horse-power the horizontal return-tubular type will be generally preferable to the water-tube or sectional variety; particularly if the plant be located at some out-of-the-way spot where first-class boiler shop facilities are not available. In fact, the writer's preference is for horizontal fire-tube boilers in all plants of 500 horse-power output and under, irrespective of repair facilities. The boilers should be set so that the fire-room is next to the engine room, although this involves maximum length of steam supply pipes.

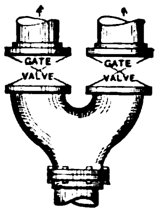


FIG. 2.

The piping for small stations should invariably be omnibused. The water suction, water delivery and live steam pipes should all lead to and from "headers," one header being used for each class, as in large plants, and as described in Mr. Ennis' recent able articles.* The live steam header should invariably be located in the engine room so that it can be got at more comfortably. The steam ends of the pumps should be supplied from this header unless doing so entails an excessive run of steam piping, which will never be the case if the plant is properly laid out. The hot feed-water header should run along the fronts of the boilers, and if more than three boilers are installed a double-header will be found extremely convenient. If only two pumps are used as advised above, the pump suction header will be a short piece of pipe extending from the suction inlet of one pump to that of the other, the suction pipe from the water supply being teed into the middle of the header, as indicated in Fig. 1. A preferable arrangement is shown by Fig. 2, but it will not always be found convenient to install.

Engineering Features at the Paris Exposition

A COMPACT ENGLISH GENERATING SET.

Among the smaller generating sets of interest at the Exposition is a 700-h.p. Galloway cross-compound vertical engine and 350-kw. Mather & Platt direct-current generator. This set, which is shown by Fig. 1, has only recently been started up; it is now running smoothly, and doing its full share in supplying current to the 250-volt bus-bars in parallel with other generators previously described.

The engine is capable of developing about 680 indicated horse-power, when provided with steam at 150 pounds per square inch, and running at 105 r.p.m. The high-pressure cylinder is 18 ins. in diameter, and the low-pressure 34 ins., both having a stroke of 36 ins. The cylinders are mounted on standards of an enclosed type, somewhat similar to that employed by the Allis people, the fly-wheel and dynamo being mounted between them.

The distribution of steam to both high and low-pressure cylinders is effected by Corliss valves, having separate steam and exhaust chests. Both sets of valves derive their motion from eccentrics fitted on extension shafts driven from the ends of the main crank pins. The whole of the valve gear is located outside of the standards, and thus, owing to its accessibility, admits of ready adjustment at any time from the outside of the engine. The enclosed design of the standards, together with the remote location of the governor and valve gear, avoids the risk of any oil, steam, or water being splashed upon the generator.

The governor, which is of the high-speed center-weight type, is positively driven from the valve shaft, and controls the expansion of steam in the high-pressure cylinder. Provision is made for the adjustment of speed by hand while the engine is running. A substantial platform is erected for access to the whole of the cylinder parts, valves, etc., and this is designed so as to give light to and convenience for lifting the dynamo parts. An efficient

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*See American Electrician for June and July, 1900.

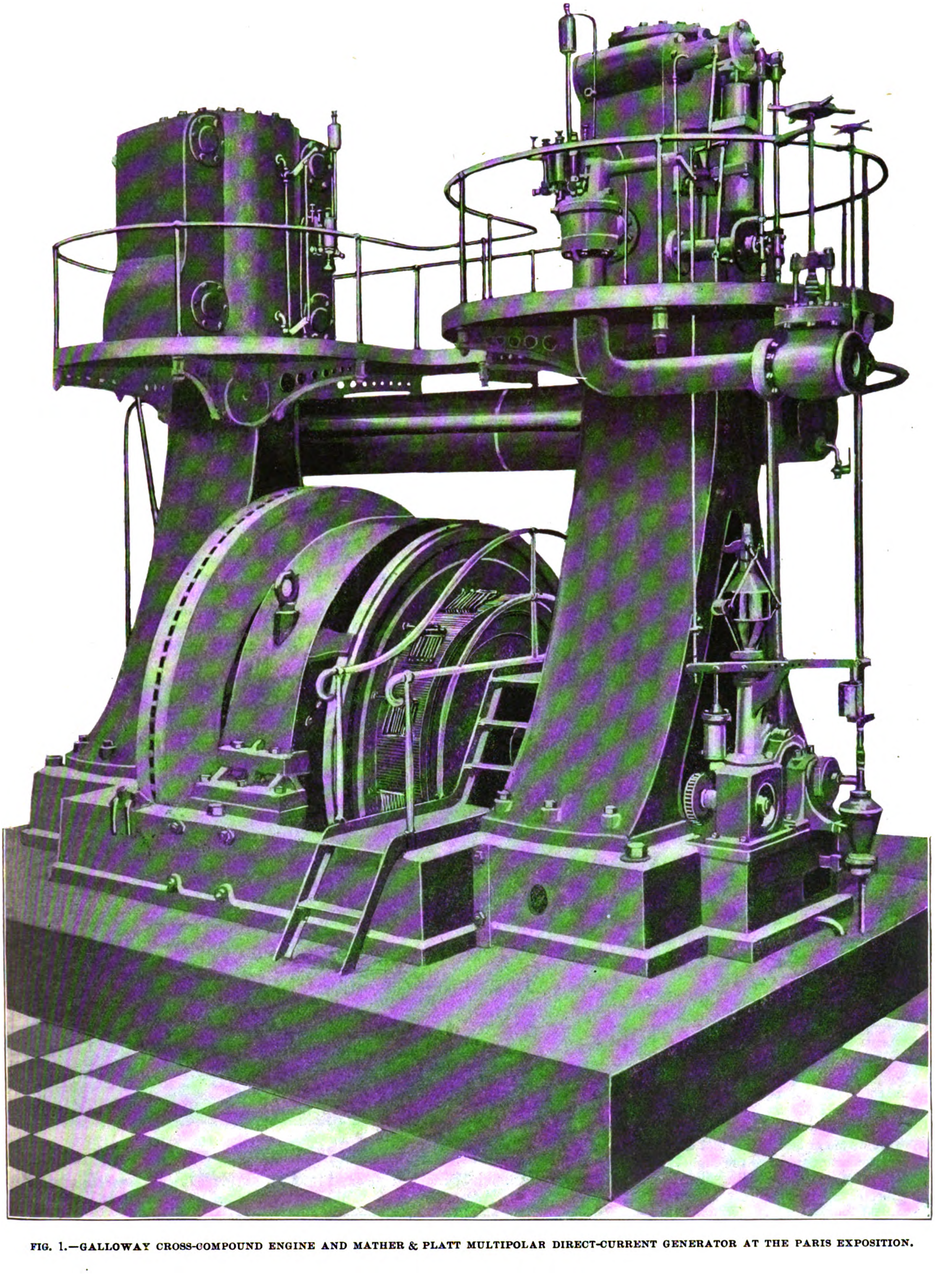


FIG. 1.—GALLOWAY CROSS-COMPOUND ENGINE AND MATHER & PLATT MULTIPOLAR DIRECT-CURRENT GENERATOR AT THE PARIS EXPOSITION.

system of forced lubrication is used, and the steam is reheated between the high and low-pressure cylinders, as indicated in Fig. 2. The condenser, of the ejector type,

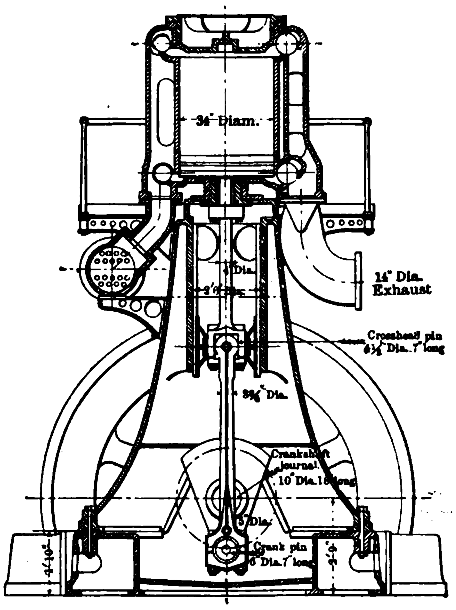

34" Diam.
5" Dia.
2'6" Dia.
14" Dia. Exhaust
Crosshead pin 6½" Dia. 7" long
3⅝" Dia.
Crankshaft journal 10" Dia. 18" long
5" Dia.
Crank pin 6" Dia. 7" long
4'10"
4'6"

FIG. 2.—CROSS-SECTION THROUGH THE LOW-PRESSURE HALF OF THE GALLOWAY ENGINE

is provided with an independently-driven water pump.

The generator is a multipolar machine, designed for use on lighting or power circuits. It is of a substantial design, and all details with regard to accessibility and compactness have been carefully considered. The machine is shunt-wound, and has an output of 250 volts and 1400 amperes, at 105 r.p.m.; it is, however, capable of carrying a temporary overload up to 1600 amperes, and is arranged to run in parallel with other generators in the Exposition. It has 12 magnet poles; the yoke ring and magnet cores are of cast steel, and arrangements are made so that the lower half of the ring can be lowered into a pit in the foundation for inspection or repair.

The armature is mounted on the crank shaft between the two main bearings. It is not keyed to the shaft, but bolted to the heavy fly-wheel, which is, of course, keyed on. This method of attachment results in all fly-wheel effects being transmitted direct to the armature instead of through two sets of keys and part of the shaft. No keys are subjected to an unnecessary strain, and a very stiff job is insured. The armature is of the slotted type, the bars being laid in insulating troughs, and entirely embedded in the iron of the core in the usual manner.

Special attention has been paid to the question of efficient ventilation, both of the armature and commutator, and the machine can consequently carry the full load for long periods with but a small rise in temperature. The commutator is of large diameter and width, and of a design and construction up to the highest standard of modern practice. The current is collected by carbon brushes, mounted in special holders, which admit of the contact pressure being adjusted as may be required, and each holder is fitted with a "hold-off" attachment. The efficiency of the generator is approximately 94 per cent which, with an engine efficiency of 91 per cent, gives a combined efficiency of a trifle over 85½ per cent.

◆

1600 KW. TRANSFORMING STATION SUPPLYING THE TRANSPORTATION SYSTEMS AT THE EXPOSITION.

The moving sidewalk and electric railroad, which form a convenient and much-appreciated link between the sections of the Exposition at Champ de Mars and the Invalides, are quite a novelty in the way of transportation to the greater part of the visitors to Paris. The electric third-rail system was adopted by the Western Railway in its Exposition extension, on the prolongation of the Orleans Railway within the city limits, and on the Metropolitan underground road; but the moving sidewalk is the only thing of its kind, and it may perhaps be said that its success is due to its Chicago predecessor, which demonstrated the possibilities of the system and suggested its use for Exposition purposes.

The electrical machinery which has been provided to supply power for the operation of the transportation systems has proved to be of wide interest, not only to ordinary non-technical visitors, who admire the large machines for their quiet powerfulness, but also to the engineering profession. The machinery for the equipment of the motor cars of the third-rail road, the 5-h.p. motors for the sidewalk, the 800-kw. 5000-volt three-phase alternators at the Moulineaux station down the river, and the transformer plant within the Exposition grounds, were all supplied by the Societe Industrielle d'Electricite, procedes Westinghouse (French Westinghouse Company) which has thus put on exhibition a complete modern system of power transmission in daily use.

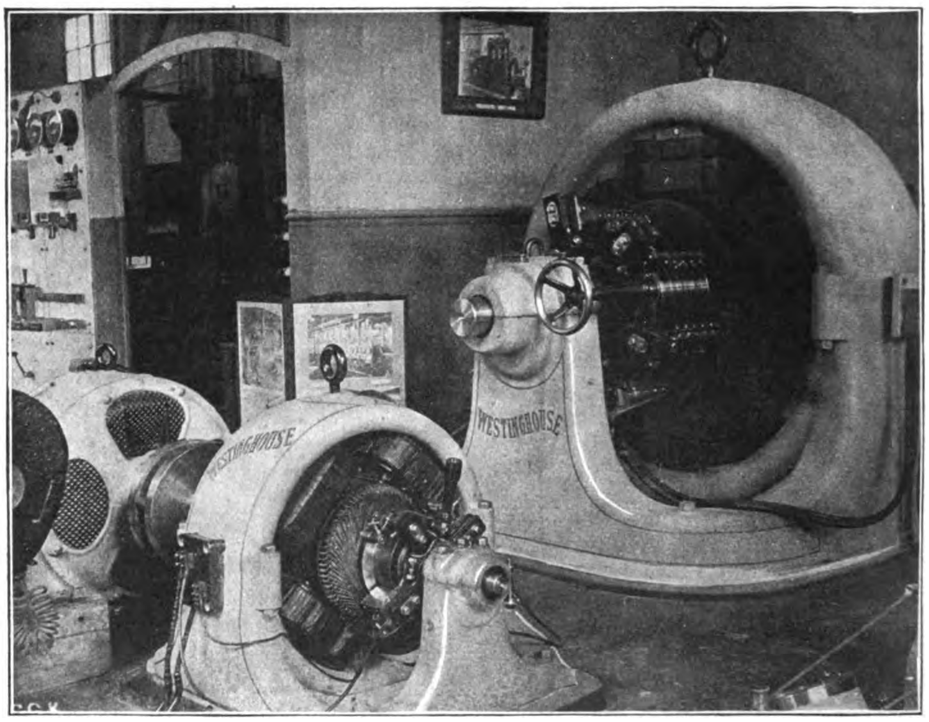


FIG. 1.—450-KW. ROTARY CONVERTER AND 30-KW. MOTOR-GENERATOR.

The sub-station contains six 10-kw. oil-insulated self-cooling transformers; two 40-h.p. type C induction motors, direct-connected to two 30-kw. 500-volt generators; six 170-kw. oil-insulated self-cooling transformers, two 450-kw. rotary converters with starting motors on their shafts, and two 850-h.p. type C induction motors direct-connected to two 600-kw. 500-volt generators. Two switchboards, with marble panels, carry respectively the high-tension and low-tension cables, switches and instruments.

The 10-kw. transformers are intended for station lighting at 110 volts and for supplying the 40-h.p. induction motors, which are started at 160 volts and then switched on to 220 volts. The 30-kw. 500-volt generators direct-connected to the 40-h.p. motors were installed to excite the large direct-current generators when starting the sidewalk with the 5-h.p. motors connected in parallel, under which condition the generator gives double full-load current at one-tenth full-load voltage. It was found, however, that the speed of the platform was too great with parallel connection of motors, and they are now run permanently two in series. The rotary converters are intended to supply power to the railroad, but as there are two of these—the whole plant being in duplicate—one is used to operate the sidewalk, for the load on the sidewalk motors averages less than 200 kilowatts. The large motor-driven set is used to start the sidewalk, because the generator field may be gradually strengthened, giving an easy start to the 180 motors under the platforms.

Current is brought to the transformer station, which is situated on the Quai

d'Orsay near the Champ de Mars, over two three-phase 5,000-volt cables of 200,000 circular mils, the power being supplied from the central station at Moulineaux. The cables enter the sub-station at the rear of the high-tension switchboard and terminate in cable headers; one of the cables is held as a reserve. From the headers the current passes through the main integrating wattmeter transformers, and is brought to two sets of standard Westinghouse generator panels, each provided with three single-pole high-tension automatic circuit-breakers having their releasing armatures connected mechanically, so that an overload in any one leg will open all three. Each set of these circuit-breakers is capable of opening a 5000-volt 800-kw. circuit. From the automatic circuit-breakers each leg of the circuit passes through a small series transformer, to the secondaries of which are connected the series coils of the indicating wattmeters as well as the three alternating-current ammeters, one for each phase. The shunt coils of the indicating wattmeters are connected to the secondaries of two shunt transformers.

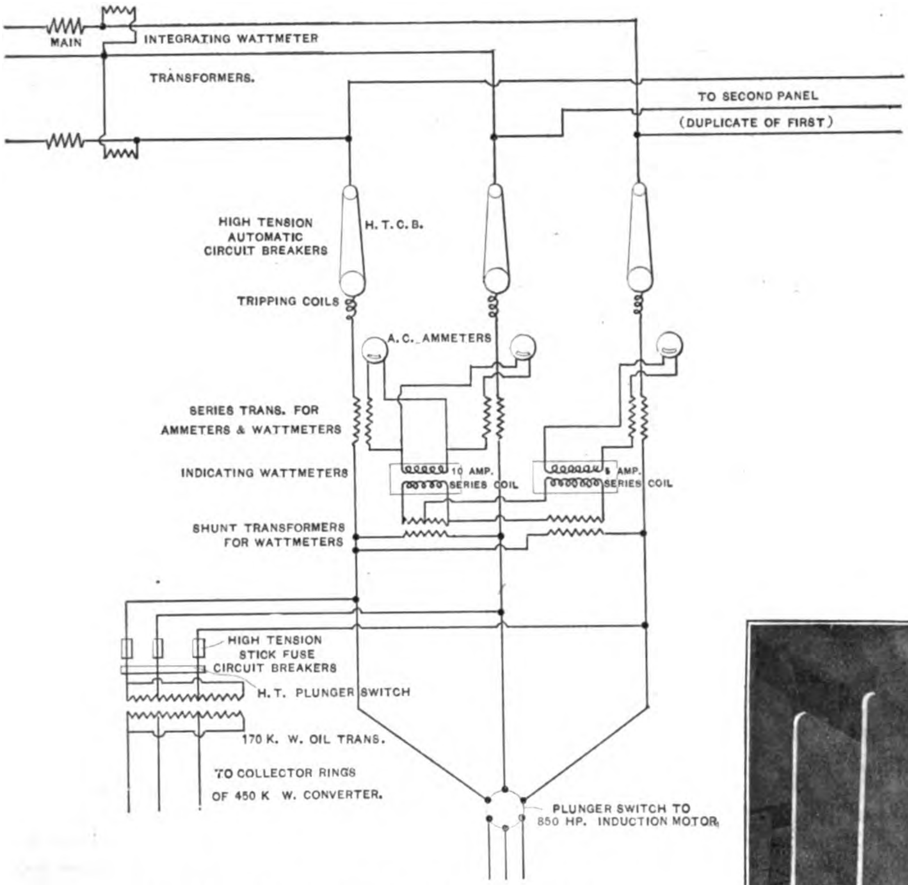

MAIN
INTEGRATING WATTMETER
TRANSFORMERS.
TO SECOND PANEL
(DUPLICATE OF FIRST)
HIGH TENSION AUTOMATIC CIRCUIT BREAKERS
H. T. C. B.
TRIPPING COILS
A. C. AMMETERS
SERIES TRANS. FOR AMMETERS & WATTMETERS
INDICATING WATTMETERS
10 AMP. SERIES COIL
5 AMP. SERIES COIL
SHUNT TRANSFORMERS FOR WATTMETERS
HIGH TENSION STICK FUSE CIRCUIT BREAKERS
H. T. PLUNGER SWITCH
170 K. W. OIL TRANS.
TO COLLECTOR RINGS OF 450 K W. CONVERTER.
PLUNGER SWITCH TO 850 HP. INDUCTION MOTOR

FIG. 2.—DIAGRAM OF A HIGH-TENSION PANEL.

Near the bottom of each panel is a **Westinghouse plunger switch, which when closed connects the primary of an 850-h.p. induction motor direct to line at 5000 volts. Before reaching this switch a lead is tapped from each leg to the primaries of the three 170-kw. transformers delta-connected, passing through fuses and a plunger switch on the way. These transformers reduce the voltage from 5000 to 330 volts for the rotary converters, which are of the standard Westinghouse pattern, each with a capacity of 450 kilowatts at 550 volts. They run at 500 r.p.m., have 6 poles, and are compound wound. On an extension of the shaft is mounted a small three-phase four-pole induction motor which serves to start the converter and bring it up to speed. As this motor has two-thirds the number of poles that the** rotary converter has, it carries the rotary above synchronism; the starting motor being cut out, the rotary is connected to the alternating-current mains as soon as it drops back to synchronous speed, as indicated by the phase lamps.

The 850-h.p. induction motors present one of the chief objects of interest in the station, as they are the largest examples of this type of motor yet built, and are entirely satisfactory and successful. **They have stationary primary windings and revolving secondaries of the squirrel-cage pattern. Three-phase current is supplied to the primary direct at 5000 volts. Each motor is connected by means of a flexible coupling to a 600-kw. 8-pole shunt-wound generator, delivering 1200 amperes at 500 volts, and running at 290 r.p.m. Compound winding is not required because the field is built up gradually in starting the sidewalk, and the load is practically constant after it is under way.**

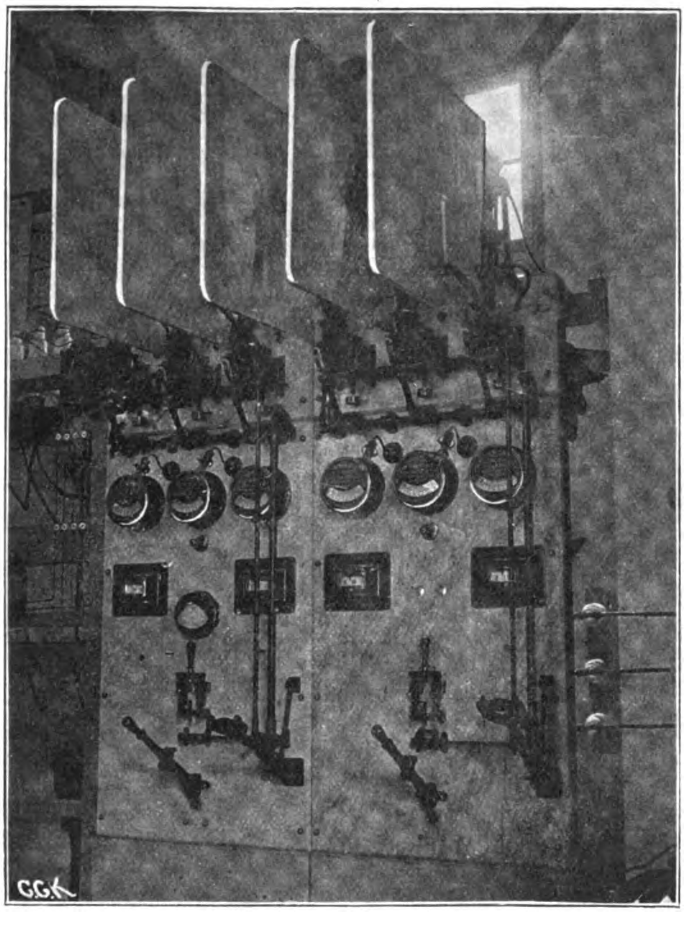


FIG. 3.—HIGH-TENSION SWITCHBOARD.

The low-tension switchboard is located in the center of the station, with the motor-generator sets and rotary converters in duplicate at each side. The board consists of thirteen marble panels mounted on an angle-iron frame, the six left-hand panels being for the rotary converters with their railway feeders, and the seven right-hand panels for the small motor-generator sets, the 600-kw. motor-generator sets and the sidewalk feeders. The middle panel of the board has two triple-pole double-throw switches and two double-pole double-throw switches, also a field rheostat for one of the 30-kw. exciters. One side of the triple-pole switches connects up with 160 volts for starting, and the other with 220 volts for normal running of the 40-h.p. motor-generator sets. One side of each of the double-pole switches is connected to the rotary bus-bars and the other side to each of the exciters, with the middle points connected in parallel and to the next panel.

Here are mounted a 600-volt voltmeter, two 200-ampere direct-current ammeters, two 100-ampere single-pole switches and two 100-ampere double-pole switches, two **voltmeter plug receptacles for the exciters, and a field rheostat for the second exciter. The middle points of the double-pole switches on the preceding panel connect to the ammeters on this panel, then to the single-pole switches which furnish exciting current to the field circuits of the large generators and to the double-pole** switches which give current to the armatures when these machines are started up as motors. The single-pole switches alone are used when running self-excited, and when separately excited the double-pole switches are used.

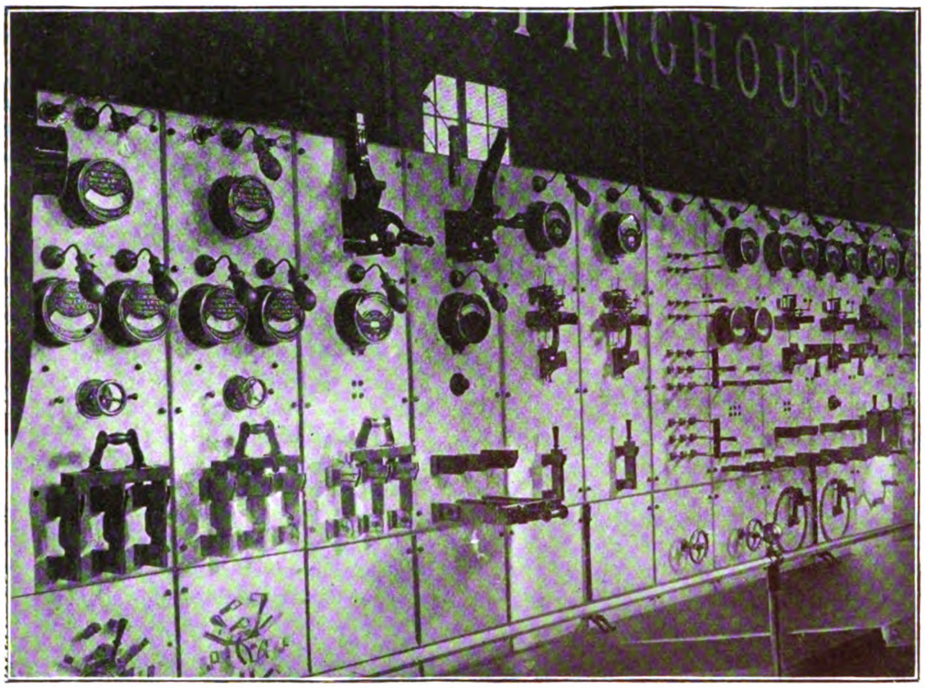


FIG. 4.—LOW TENSION SWITCHBOARD.

At the end of the board which controls the rotary converters is a 600-volt direct-current voltmeter, swung on a bracket at an angle with the board so as to be visible from any point of the board. This voltmeter is connected to the receptacle on each of the direct-current rotary panels and serves to indicate the voltage of the rotaries.

For supplying the Exposition third-rail road one of the 450-kw. rotary converters is ordinarily used, started by means of the three-phase starting motor as already described. The moving sidewalk is also normally supplied by the second rotary, although for starting it one of the larger motor-generator sets is used. This is itself started from the direct-current end by current taken from the rotary already in operation. When synchronous speed is reached the direct-current is cut off and the plunger switch closed, thus throwing the induction motor across the 5000-volt mains. The sidewalk is then started by closing the generator circuit-breaker and main switch—the feeder switches and circuit-breakers being already closed—and then cutting out gradually the field rheostat, thus building up the voltage and current slowly. The sidewalk starts ordinarily at about 180 volts and 900 amperes, the current immediately dropping to about 300 amperes at 500 volts, which is normal under usual conditions. After the sidewalk is running at normal speed, the 600-kw. generator is paralleled with the second rotary converter and the load transferred to the latter, the motor-generator set being then shut down.

This transformer station has been in continuous operation since the opening day, April 14th, the machines supplying current unfailingly and running from 8 o'clock in the morning until nearly midnight. The rotary converters especially are giving good service, as practically all the load is carried by them. M. Maurice Coster, who directs the operations of the Westinghouse Company in Paris, is to be congratulated on such a good showing being made in this installation.

For many courtesies extended and opportunities afforded for the examination of the transformer station, the writer is indebted to J. T. Wolfe, in charge of the work, and to Messrs. Leo. A. Phillips, Carl G. Koppitz and W. A. Brown, engineers of the station, who have supplied much valuable information relative to the working of the plant.

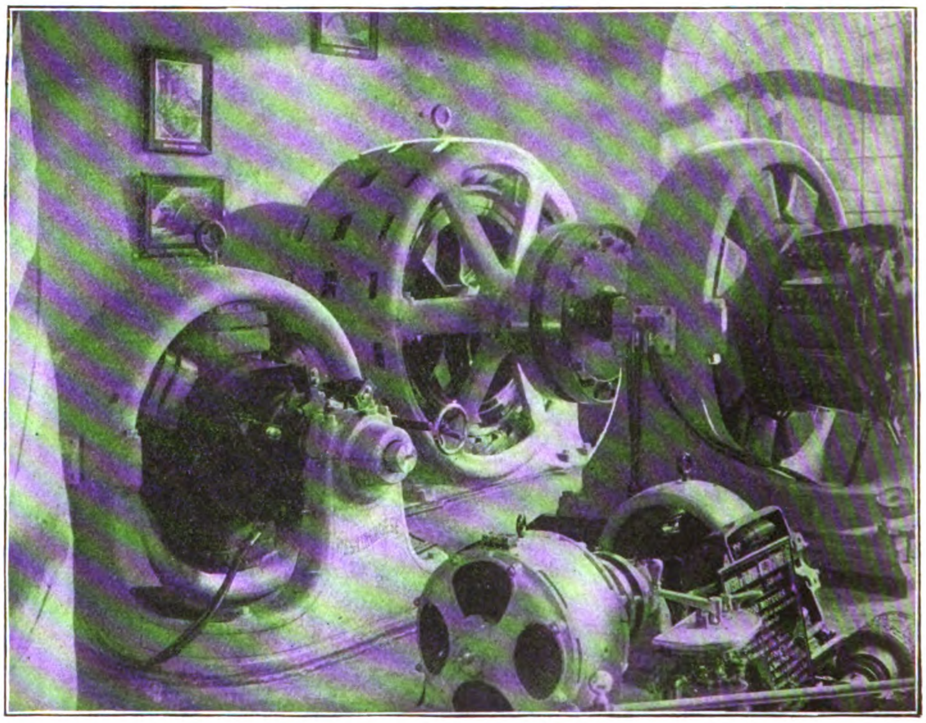


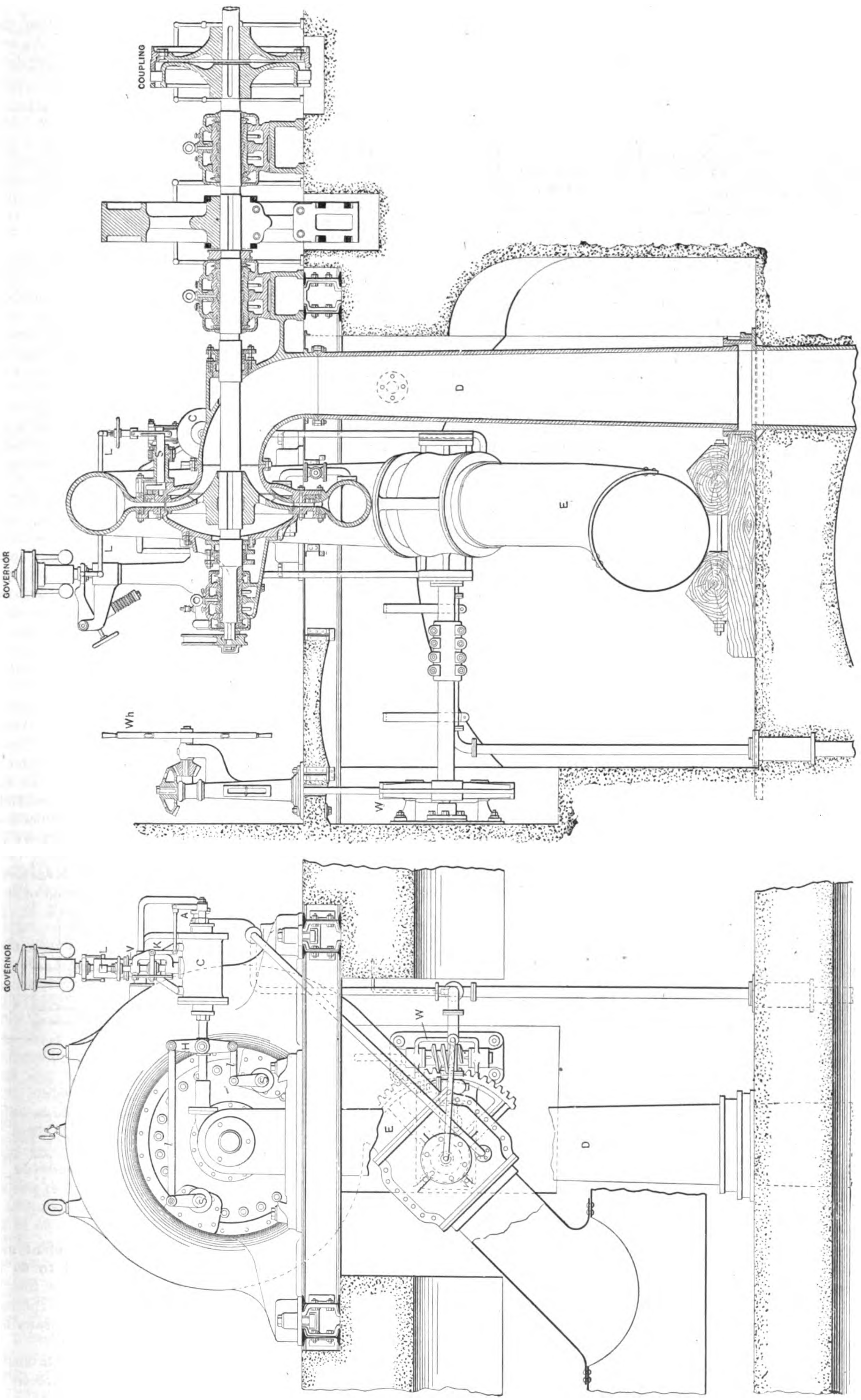
FIG. 5 —VIEW SHOWING 600-KW MOTOR-GENERATOR SET.

A 1000-H.P. TURBINE.

In the foreign section, Ganz & Co., of Buda-Pesth, exhibit an interesting hydraulic turbine, equipped with a hydraulic relay governor. Fig. 1 is an end elevation and Fig. 2 is a partly sectional side elevation. (See opposite page.)

The water enters tangentially at the lowest point, E, of the casing, the supply being controlled by a heavy valve actuated by the worm, W, and segmental worm gear. The worm is turned from the platform above it by the capstan wheel, Wh, Fig. 2, through bevel gears. The water flows around the outer casing and inward from it through the guide blades surrounding the wheel, the section of the casing becoming smaller and smaller at points of the periphery farther away from the main inlet. The wheel blades are curved principally in the plane of rotation, being curved but slightly in the axial plane in order to lead the water into the central outlet casing. The water enters this casing axially, the axial curvature being continued in the passage lying between the wheel hub and the upper walls of the outlet casing. This latter part of the axial curvature has no driving effect, the wheel blades not being carried through it. Thus the turbine is mainly an inward flow machine. The discharge turns vertically downward after getting clear of the wheel, and a vacuum may be obtained in it corresponding to the level of the tail-race.

The passages between the wheel blades have an axial length of about 2 ins. only, while the outside diameter of the wheel is 44⅞ ins. The diameter of the inlet casing, which is circular in each radial section is 27 9/16 ins. at the main inlet valve, 19 11/16 ins. at the top of the casing, and decreases to 13 25/32 ins. at the tail end. The diameter of the outlet is 20 15/32 ins. at the level of the turbine shaft; the diameter of the draft-tube, D, however,


COUPLING
GOVERNOR
L
S
C
L
D
E
Wh
W
GOVERNOR
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K
A
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S
W
E
D

FIGS. 1 AND 2.—GANZ 1000-H.P. HORIZONTAL TURBINE AT THE PARIS EXPOSITION.

increases to 30½ ins. about 23 ft. lower down, where it is intended to discharge from 20 to 30 ins. beneath the surface of the water of the tail-race. This increase in the diameter of the discharge tube conduces to a quiet discharge into the tail-race at a very low velocity. The decrease of velocity from top to bottom of the draft-tube is, of course, not directly utilized by impulse on the turbine blades, but it increases the vacuum below the turbine, and thus indirectly increases the effective power by increase of inlet velocity. This effect is, at any rate, produced so long as the draft tube, D, runs full bore.

The main shaft is scant 7½ ins. in diameter in the two main bearings between which the fly-wheel is mounted, and about 5⅛ ins. in the small bearing on the left of the turbine, Fig. 2. It is increased to 8¼ ins. in the turbine hub. Beyond the fly-wheel the power is taken off through a flexible coupling constructed of two discs 55 ins. in diameter, from each of which project pins coupled in pairs—one of each pair in each disc—by stout leather band links. This is the favorite form of flexible coupling at the Exposition, the links being sometimes of cotton belting, and, for light work, of rubber. The bearings are lubricated by large-sized rolling rings dipping deep into an oil well fashioned in the plummer block.

The governor is a sensitive one, belt-driven at moderate speed. It controls the piston in the hydraulic relay cylinder, C, by means of the lever, L, which at the middle of its length moves the admission piston valve, V. The valve, V, admits high-pressure water to either end of the relay cylinder through copper tubes. The end of the lever, L, over the relay cylinder (see Fig. 2), which end acts as the fixed fulcrum in each initial movement of the lever, is floated by the relay piston. The piston-rod passes through a stuffing-box in the back cover, and by the crosshead arm, A, and the bell-crank, K, supports, as stated, the fulcrum pin of the lever. As soon as the piston moves, the lever is given a small motion in the direction opposite to that which has opened the admission valve, and thereby this valve is again closed after a certain small piston motion has taken place. An adjustment by handwheel and screw is introduced between the bell crank and the lever fulcrum.

The piston-rod, passing through the front cover of the relay cylinder, moves the equal-armed lever, H, and this, through the links, 1 1, turns the two shafts, S S. (In the sectional elevation, Fig. 2, the upper shaft, S, is, for convenience of sectioning, shown as if it were on the vertical diameter of the turbine, which is not its true place.) These two shafts, by means of cranks keyed on them inside the casing, turns the crown ring carrying the shutters which regulate the areas of the admission ports to the guide blades.

Under a head and fall of from 225 to 244 ft. and at a speed of 300 r.p.m., this turbine develops under test 632 effective brake horse-power. At the higher speed of 320 r.p.m. and a correspondingly greater head and water supply, it develops 1000 horse-power.

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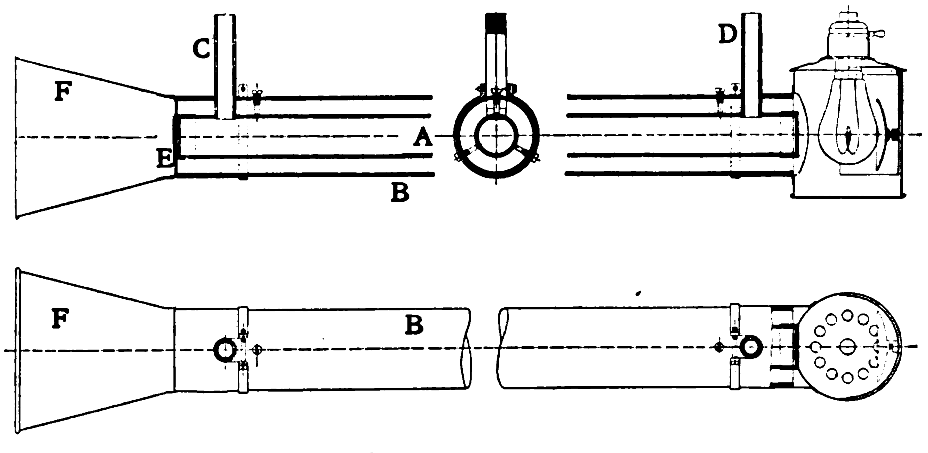
A SMOKE DENSITY INDICATOR.

The Austrian Society of Steam Boiler Owners of Vienna exhibits in the Austrian section in the Electrical Building of the Paris Exposition an interesting apparatus for indicating the density of smoke. The object of this apparatus is to indicate to the fireman the character of the flue gas so that he may regulate his fire to obtain maximum combustion. But the apparatus has, incidentally, another advantage, namely, it enables the fireman to conform to the requirements of anti-smoke ordinances in cities where such regulations are imposed.

It is well known that the production of smoke is always the result of insufficient air supply to effect complete combustion, or of an improper mixture of the air with the gases distilled from the combustible. In any furnace which is fed periodically there is always a period at which there is no development of smoke. It does not follow, however, that the conditions of combustion are then especially favorable. This is only the case at the beginning of the period of smokeless combustion. But as the combustion advances and consequently the layer of coal on the grate gets thinner, there is an excess of air admitted, which gradually increases.

As a result of this excess of air the temperature in the furnace is considerably reduced. That part of the air which is not utilized in combustion has to be raised to the temperature of the flue gases and the heat necessary for raising its temperature to this point is lost. This constitutes another important loss, and one which does not make itself known by any directly visible signs. In the accompanying table an admission of 1.3 times the air theoretically required for complete combustion is considered as normal; that is to say, it is supposed that there are no losses when the air is admitted in this proportion.



FIGS. 1 AND 2.—SMOKE DENSITY INDICATOR.

As has already been stated, in all furnace installations which are fed periodically, there is a spontaneous transition from combustion, accompanied by smoke production, to smokeless combustion. It is at this period of transition that the combustion is effected under the best conditions, and at the highest efficiency. To maintain a high efficiency this period must be regularly reproduced. This result is obtained in the simplest manner by restricting the admission of air, by partly closing either the flue dampers or the draft gates, but the fireman has to know at what moment and to what extent this needs to be done.

Ratio of admitted air to theoretical quantity....	1.3	1.5	1.9	2.4	3.2
Surplus beyond 1.3 times theoretical	0%	15%	46%	85%	146%
Loss of heat in flue gases.	12%	14%	18%	23%	30%
Loss of combustible..........	0%	2%	6%	11%	18%
Proportion of carbon dioxide in flue gases. ..	15%	13%	10%	8%	6%

The smoke density indicator, the design of which is based upon the theory outlined above, gives the indications necessary for properly regulating the air admission.

This apparatus shows exactly at what moment the smoke production decreases, and when it ceases entirely, and indicates, therefore, the time when one should begin to reduce the admission of air. It indicates also the degree to which the air admission must be reduced, as it will show immediately any smoke that may be produced, and thus permits the fireman to observe exactly and continuously what is going on in the furnace.

Up to the present most central station men have been content to observe the gases as they leave the chimney, a method which has been recommended by a number of engineers of high standing, but which is nevertheless insufficient for an exact regulation of the process of combustion, and which fails entirely in many cases, as, for instance, when one chimney serves a number of furnaces. Moreover, a continual observation of the chimney is much too inconvenient and as it takes the gases from 20 to 60 seconds, and often even more, before they are visible at the mouth of the chimney, this is evidently not a proper means by which to regulate the furnace.

On the other hand, the intensity indicator may be attached directly to the boiler front, or at the side of the boiler, in such a manner that it may be read conveniently, so that it obviates the necessity for any special effort on the part of the fireman to observe and regulate the working of his furnace.

The smoke intensity indicator consists essentially of a straight tube, A, Figs. 1 and 2, of 1.6 to 2 ins. diameter, and 40 ins. length, hermetically closed at both ends by circular glass discs. At the two ends of this tube are fastened two small tubes, C and D, by way of which part of the gases from the furnace enter and leave the long tube. One of the small tubes, the one by which the gas enters, communicates directly with a pierced tube leading to the combustion chamber, while the other tube, by which the gases are led away from the indicator, leads to the chimney or terminates in a special draft-creating apparatus.

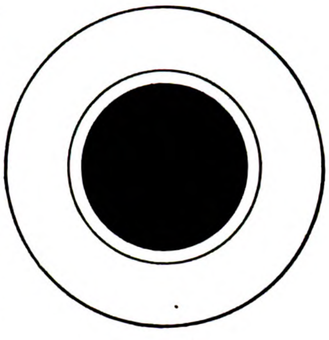


FIG. 3.

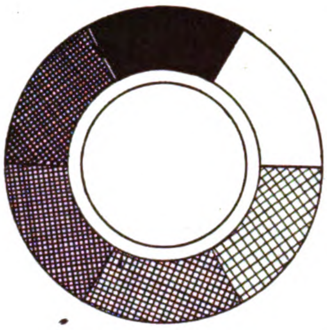


FIG. 4.

If one looks through the tube, A, at a source of light placed at the outer end of the tube, and in line with the axis of the latter, the source of light will be more or less obscured, according to the density of the smoke passing through the tube. Eventually the source of light may be entirely invisible. The indications of the occurrences in the furnace are so rapid that often in less than a second after coal has been thrown into the furnace, or some other change has been made, one may ascertain whether smoke is produced in the furnace or not.

In this type of smoke-intensity indicator the observer has to place his eye in line with the axis of the tube to perceive the obscuring of the light. To evade this restriction the indicators are provided with a disc, E, of glass or of other transparent material, which is shielded against extraneous illumination by a funnel, F, of sheet metal. To make the indications of the instrument more distinct, the tube, A, through which the gas passes, is surrounded by another larger tube, B. This outer tube does not conduct any gases, but light from the luminous source passes through it and falls upon the transparent disc, E, which has the same diameter as the interior of the tube, B.

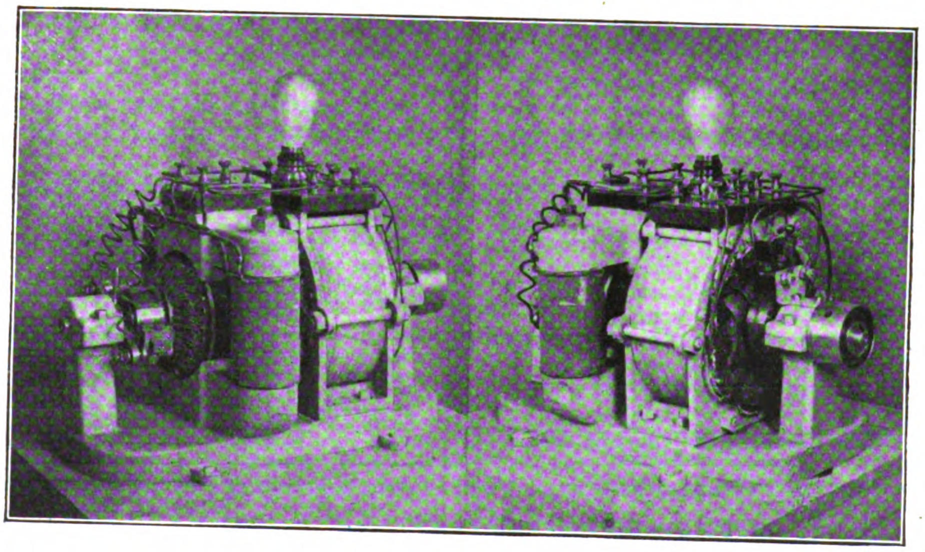
In the case of absence of smoke the transparent disc shows two concentric circles of uniform illumination. In case of a little smoke the interior circle is less strongly illuminated than the exterior circle and is of a light gray or dark gray color, and is entirely dark when there is an intense smoke, while the illumination of the surrounding annular space does not change. This last named condition is represented by Fig. 3.

On this principle may be based a very simple and certain method of measuring the intensity of the smoke. The annular circle of the transparent disc, E, is divided into sectors, which are shaded, with the exception of one, which is left plain. The shading of the sectors is done in such a manner that, starting from the one without shading, each sector is darker than the preceding one, up to the last, which is entirely dark, giving a scale of smoke intensity, as shown in Fig. 4.

The scale published by Prof. Ringelmann is often used for observations on the intensity of smoke. He represents the different shades of gray by black lines on white paper, the lines crossing each other at right angles. These drawings, looked at from a certain distance, represent the different shades of gray corresponding to the different intensities of smoke. Such a method of measuring and comparing the intensity of smoke offers considerable advantages. The width of the lines and of the spaces between being given, anyone can draw these diagrams for himself, but they are also being printed, it is claimed, in France and in America.

The following is the scale of Prof. Ringelmann:

No. 0. No smoke. Entirely white.
No. 1. Light gray smoke. Lines of 40 mils width with intervals of 360 mils.
No. 2. Smoke of a darker gray. Lines 92 mils wide, with spaces between of 308 mils.
No. 3. Very dark gray smoke. Lines of 148 mils width, with intervals of 252 mils.
No. 4. Black smoke. Lines of 220 mils width with intervals of 180 mils.
No. 5. Entirely black smoke. Solid black.



FIGS. 1 AND 2.—THE MOTOR-GENERATOR.

This scale of smoke density, which, according to Bryan Donkin, is the best, is often employed in France. To make the observation it is desirable that one observer notes the characteristic circumstances of the firing, the time of adding coal, etc., while the other observes the smoke produced. In case of a boiler test, lasting, say, eight hours, observations should be made every minute, and the results may be plotted on cross-section paper with the abscissae representing time.

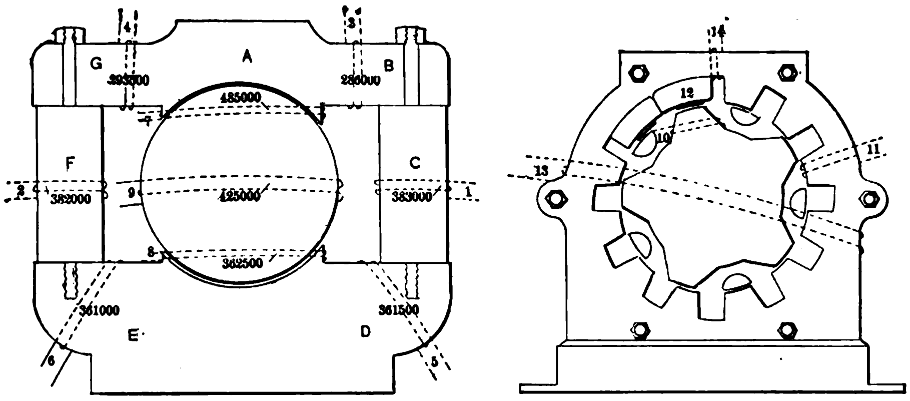
By noting which sector of the scale has the same luminous intensity as the central part of the glass disc, E, one obtains an accurate idea of the actual intensity of the smoke. If the transparent disc, E, be replaced by a disc with a scale, as described above, the intensity indicator may be used for measuring directly the intensity of the smoke.

The smoke intensity indicator here described is made in a number of forms, to adapt it to various kinds of installations. Where there is only one boiler, or two, it is placed at the side of the boiler, but when there is a large battery of boilers it is connected in front of the boilers in such a manner that the fireman in looking at his water glass and pressure gauge sees also the intensity indicator without special effort.

SOME EXPERIMENTS WITH A MOTOR-GENERATOR.

BY W. E. PARKER AND F. W. GROVER.

The following tests were made with a motor generator built from the design published in the American Electrician for May, 1898. Figs. 1 and 2 were made from photographs of the machine, and the diagrams, Figs. 3 and 4, give a good idea of its general construction. The direct-current end is of the common type, but the alternating-current end is of somewhat unusual construction. The alternating-current armature is stationary, and is built up of stampings of 9½-in. rings with a 6-in. hole. The rings are slotted on the inside with 12 slots, and over each tooth so formed is placed a coil of wire. The 12 armature coils are wound in reverse order, and are so connected as to form a closed circuit. If connection be made with the armature at two opposite points, the current in the external connecting circuit will be single-phase, alternating. Two such circuits connected at right angles will convey currents in quadrature. By connecting at points 120 degrees apart, three-phase currents will be obtained.



FIGS. 3 AND 4.—SHOWING TEST COIL POSITIONS.

The field revolves within the armature and consists of two five-pointed star-shaped iron castings, exactly alike, mounted facing each other on the shaft with their fingers interlaced, thus giving a 10-pole field. The field coil is wound upon a spool, which is placed within the casting before the field is assembled, and current is led into the field by means of collector rings and brushes.

The machine, when connected to run as a direct-current motor at 110 volts, started off at a speed of about 2650 r.p.m., and at this speed, over twice that anticipated and with one ampere in the alternating-current field, the generated alternating e.m.f. was about 80 volts. This did not agree very well with the behavior predicted for the machine, and in the electrical laboratory of Wesleyan University, under the direction of Prof. E. B. Rosa, a series of tests was made, which tests show the cause of the discrepancy and are very instructive.

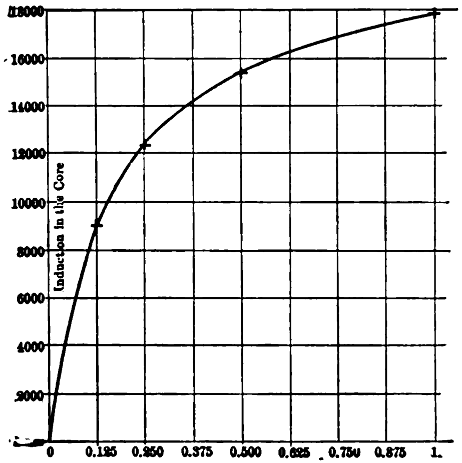


FIG. 5.—MAGNETIZATION CURVE.

First, the number of lines of force through the various parts of the direct-current magnetic circuit was measured by means of the ballistic galvanometer. In the measurements the iron was carried through a cycle, the current being made, broken, made in the opposite direction, and again broken. Two cycles were taken with each coil, the results being accordant to less than 1 per cent. In a few cases cycles were taken with the same coil on two different days, and were found to give an accordance as good as that above. The position of the test coils is shown by the dotted lines of Fig. 3.

The current in the field was one ampere, the normal current according to the design. The number of lines found through test coil No. 1 were 383,000; through coil No. 2, 382,000 lines; through coil No. 3, 286,000 lines; through coil No. 4, 293,500 lines; through coil No. 5, 361,500 lines; through coil No. 6, 361,000 lines; through coil No. 7, 485,000 lines; through coil No. 8, 362,500 lines, and through coil No. 9, 425,000 lines of force. That is to say, of the 765,000 lines developed by the field coils, only 425,000, or 55.55 per cent passed through the armature, which shows a very great leakage.

The possible paths of leakage are, first, in air from one end of the field coil to the other; this is probably small; second, through the bed plate into the stampings which form the alternating-current armature and thence across to A, Fig. 3. Part will also leak from the stampings into the direct-current armature. That this actually takes place is shown by the fact that a larger number pass through coil 9 than through coil 8. Some will pass from B and G directly into the alternating-current armature stampings, and therefore the number through coils 3 and 4 will be less than the number through coils 1 and 2.

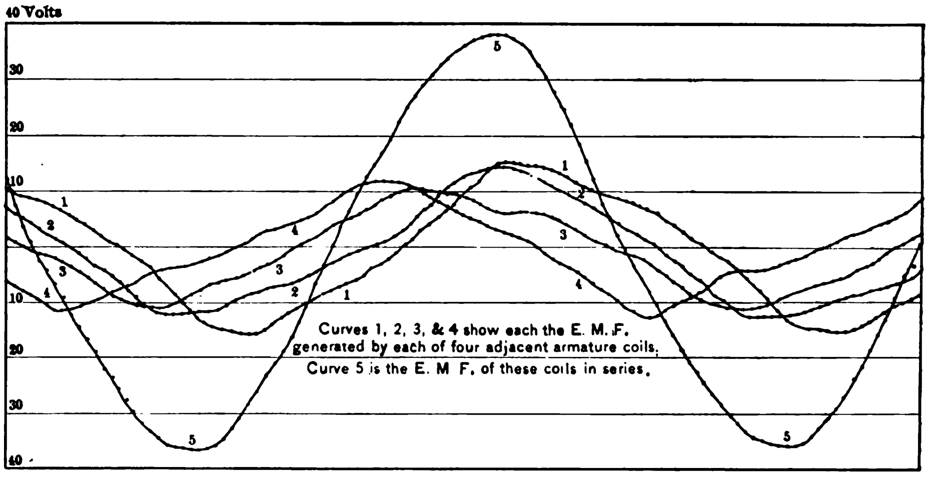


FIG. 6.—E.M.F. CURVES FROM FOUR COILS; SEPARATE AND COMBINED IN SERIES.

To ascertain if the greater part of the leakage did in fact pass through the alternating-current armature stampings, coils were placed about them in the positions shown by the dotted lines in Fig. 4. The number of lines through coil 11 due to the direct-current field was 58,200, while 122,600 passed through coil 13, which was wound completely around the diameter of the alternating-current stampings. It will be noticed that the number which pass through coil 11 is less than one-half the number through coil 13, which would seem to indicate, as supposed above, that some lines leak directly from the stampings into the direct-current armature. To ascertain if the peculiar behavior of the machine was due to a poor quality of iron, tests were made, the results of which are shown by the magnetization curve, Fig. 5.

These measurements were taken with the fields magnetically in series, the lines of force passing around by the path C, D, E, F, G, A, B, Fig. 3. They show that the iron was approaching saturation with one ampere in the field winding; also that the quality of the iron is very good, for 17,800 lines per sq. cm. is large induction for very good iron. The cast iron in the parts B and G, Fig. 3, was carrying about 12,000 lines per sq. cm. with the normal field current, which is as large an induction as can reasonably be expected of cast iron.

Next a series of measurements was made with the alternating-current field, while the normal current of one ampere was flowing. The number of lines through coil 10, which was placed around one of the fingers of the field, was found to be 36,300 in one finger, in another, 36,900. It appears, therefore, that the lines were pretty evenly divided between the fingers. A finger was put directly under an armature coil, and the number of lines through coils 12 and 14 (see Fig. 4) was measured. Two armature coils were experimented on. The number through the armature tooth in one case (coil 12) was 21,100, while 10,600 passed through test coil 14, almost exactly one-half, as would be expected, since the lines of force passing through the armature core would divide, having two similar paths through the stampings. Another armature coil gave 18,500 lines through its tooth, while almost exactly half (9080 lines) passed through a test coil wound round the stampings near it.

Since out of about 36,000 lines passing through the fingers, only about 20,000, or 55 per cent, pass into the armature teeth, the rest must leak between the field magnet pole fingers. It is to be noticed that the two armature coils did not give very concordant results.

Evidently the same number of lines of force does not pass through each armature coil. This seems to be due to some lack of symmetry in the machine. That such is the case is indicated by the e.m.f. curves drawn for individual armature coils. These curves, which are shown in Fig. 6, were drawn by Prof. Rosa on a Rosa curve tracer.* Curves 1, 2, 3 and 4 show the e.m.fs. generated by each of the four adjacent armature coils forming one of the three-phase circuits. The points drawn by the tracer in these curves have been connected by a full line to prevent confusion. Curve 5, however, which represents the resultant of the voltages of the single coils, has been left untouched, and gives an idea of the work as actually done by the tracer. Fig. 7 shows the form and phase difference of the two-phase waves, while Fig. 8 gives the same for the three-phase pressures.

From Fig. 6 it will be seen that the curves generated by the individual armature coils show great irregularities. Not only are the forms and heights of the curves very different, but the successive loops of the same curve are quite lacking in uniformity. The average values of the e.m.fs. obtained by taking a mean of the ordinates of the points drawn by the tracer (the positive loops only of the four curves being taken) were for curve No. 1, 8.90 volts; for curve No. 2, 7.57 volts; for No. 3, 6.32 volts, and for No. 4, 6.18 volts.

The effective resultant, obtained approximately by taking 7/10 of the maximum ordinate, is about 27 volts. If the machine were symmetrical, the four curves, although differing in phase one from another, should show the same voltage for each coil.

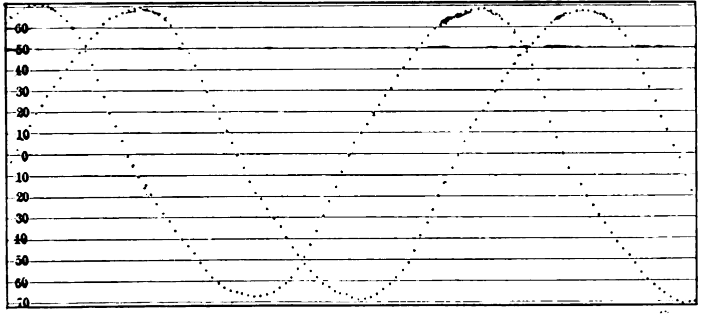


FIG. 7.—TWO-PHASE WAVE CURVES.

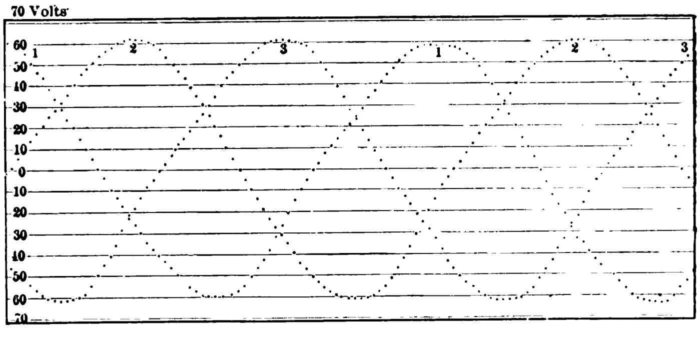


FIG. 8.—THREE-PHASE WAVE CURVES.

The variable distribution of lines of force between the several pole-pieces and armature coils may be explained by the plausible assumptions, first, that the pole-pieces of the field are not all of the same size and shape. This would cause variation in the density of the fields, due to the different pole-pieces; second, that the air-gaps, between a given armature coil and different pole-pieces or between the same pole-piece and different armature coils, are variable in thickness or length. The variation in the case of a single armature coil and different pole-pieces would explain the difference between consecutive loops of the same curve, the loops being produced by as many different pole-pieces. The variation of the air-gap between the same pole-pieces and different coils would explain the difference between the several curves. Any notable eccentricity of the field or the shaft, or the armature about the shaft, would be sufficient to make these assumptions valid; third, the cores of the armature coils may be of different sizes and shapes. This would tend to cause the observed differences of wave form of the curves. By an inspection of Figs. 7 and 8 it will be seen that the lack of symmetry of individual curves, and differences in form of the different curves, is traceable in these curves also.

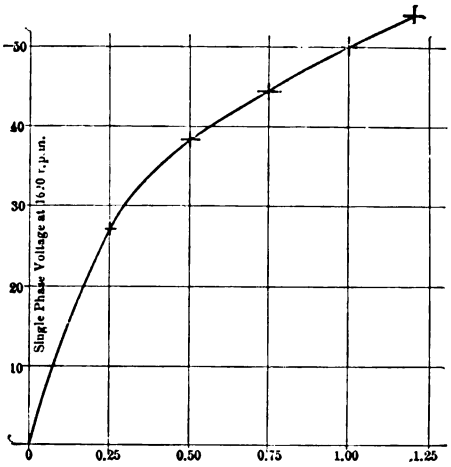


FIG. 9.—EXCITATION CURVE

From what has gone before, we may see that the machine can act neither as a direct-current nor as an alternate-current motor or generator at 110 volts at a speed of 1200 r.p.m., as was intended. For running as a direct-current generator at 1200 r.p.m. (20 per sec.) the 576 wires about the armature will cut the 425,000 lines through the armature twice during each revolution, and since the halves of the armature are in parallel, the calculated e.m.f. is 48.9 volts; at this speed we observed 47.5. At 1650 r.p.m., the machine should give 67.3 volts, and we observed 65. As a direct-current motor at 110 volts its speed should be 2694 r.p.m.; we observed 2650. At 50 volts the speed should be 1200 and we observed 1164. Running as a single-phase, synchronous motor at 110 volts and generating direct current, we could take from the machine only 2.75 amperes at 55 volts, without throwing the machine out of step.

We may also show that the alternating current end cannot give 110 volts at 1200 r.p.m. For, take 20,000 lines as a good average value of the number of lines which pass through an armature tooth and consider the action of one coil when the field has made one-tenth of a revolution; 20,000 lines will have cut the coil in one direction and 20,000 lines in the opposite direction; in other words, 20,000 lines will have cut the armature coil of 98 turns twice; and running at 1200 r.p.m. the e.m.f. induced per coil should be 7.84 volts. This compares very well with the value taken from Prof. Rosa's curves already given. Each coil will therefore develop 7.84 volts, and since the armature is in parallel, it will give the e.m.f. of six coils in series, but since they all differ in phase, the total e.m.f. will be less than 6 times 7.84, or 47.70 volts average, or, say, 52 volts effective e.m.f. The values actually observed were as below, at 1620 r.p.m.:

Current in A. C. field.	Voltages by Cardew V. M.
0.25 amp.	27.
0.50 amp.	38.5
0.75 amp.	44.25
1. amp.	50.
1.2 amp.	54.

In this part of the machine also we are working well up on the bend of the magnetization curve, see Fig. 9, for to double the voltage we have had to multiply by the field current by 4.8.

Now, assuming no leakage, the number of lines required through the direct-current armature in order for the machine to act as a generator or motor at 110 volts and 1200 r.p.m., would be 955,000, which is more than twice the number developed by the field coils. Hence, if there were no leakage with the present field, the voltage of the machine would still fall far short of 110. It would be, in fact, only 88.0. Assuming 15,000 lines per sq. cm.

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*Phys. Review, January, 1898.

as a good magnetic density and that 70 per cent of the generated lines pass through the armature, the diameter of the magnet cores required would be 3 ins. The dimensions of the yoke connecting the cores would have to be increased correspondingly.

If the machine running at 1200 r.p.m. is to generate 110 volts, alternating current, then owing to the differences in phase the average e.m.f. developed by each of the twelve coils forming the alternating-current armature must be greater than one-sixth of 110, and the number of lines per pole must be increased to more than 46,700, say 50,000; if there were no leakage, assuming an induction of 10,000 lines per square centimeter, the diameter of the field core should be 3.1 ins. Assuming a leakage of 30 per cent as in the case of the direct-current end, the required diameter is 3.76 ins., and with the 55 per cent leakage, the diameter of core required is 4.23 ins. Since the diameter of the field core must be increased by more than two inches, it is evident that in order that there be room for the field coil, the over-all diameter of the field castings must be increased, necessitating a corresponding increase in the armature stampings.

A machine of the same type of construction, but built with a heavier shaft, with an increased distance between the alternating - current and direct - current parts, together with the modifications already suggested, would prove very satisfactory. Of course, the leakage in a field of the form used in the alternating-current part is considerable.

Anyone contemplating the construction of this machine could not do better, so far as the alternating-current part is concerned, than to follow the excellent design of a similar machine built by Prof. Henry S. Carhart, and described in the American Electrician for November, 1897.

In conclusion, we wish to emphasize the fact that nothing like a complete test of the machine was attempted. The work was undertaken merely to ascertain why the machine failed to do the work for which it was designed. Our sincere thanks are due to Prof. Rosa, to whose help and suggestion we owe in great measure the results obtained.

Abstracts from Foreign Contemporaries

Manufacturing Glass Electrically.—In a recent issue of the "Elektrotechischer Anzeiger" Dr. Bermbach gives some information about experiments made by a German company with a method devised by Becker of manufacturing glass by means of the electric arc. A diagram of the Becker electric furnace is given in Fig. 1. The raw material is filled in powdered form into the funnel and flows upon the highest step of the stairway, where it is fused by an electric arc; to clear and purify the fused mass of glass it is run down two other steps and is there acted upon again by electric arcs; the operation is continuous. In the experiments the three arms were connected in parallel, the voltage being 120 and the current going up to 360 amperes. The carbons were 16 ins. long and 1.5 ins. in diameter. As their consumption was slow and the arcs could attain a length of 2 ins. when the fused mass was flowing directly below the arcs, it was not necessary to provide means for automatically keeping the distance of the carbons constant. No obnoxious influences due to electrolysis were observed.

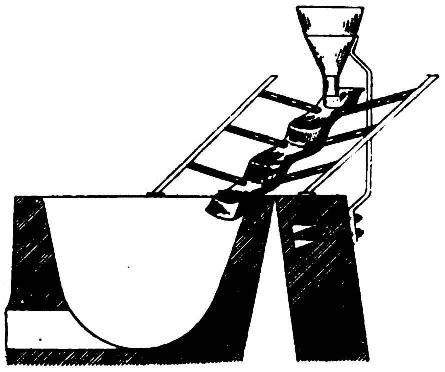


FIG. 1.

Compound Lighting and Traction Plant.—In a recent issue of the London "Electrical Review" attention is called to the difference of opinion between British engineers whether a combined station is advisable: Glasgow and Cardiff are erecting separate stations, while Manchester and Southampton are combining the two systems, although in the latter case the lighting supply is with alternating current. The writer reaches the conclusion that for small townships, where neither lighting nor power nor traction is likely to ever attain large proportions, there can be no doubt as to the advisability of combining the works, as far as possible, and placing the whole under the supreme control of an electrical engineer; a smaller engineering staff will thus suffice for the joint undertakings. When, however, traction and lighting are carried on upon a large scale, it is thought that the engineers must specialize, as one man cannot be responsible for the two extended departments.

A very successful combined lighting and traction plant on a large scale is that at Prague, Austria, as described by Mr. Kolben in a recent issue of the "Elektrotechnische Zeitschrift." It furnishes electrical energy from one class of machines and one set of bus-bars for traction, stationary power and public and private lighting services. The plant will have five steam-driven three-phase generators, each of 750 to 1000 horse-power, and five others, each of 1500 to 2000 horse-power ability. The three-phase currents are generated and transmitted at 3000 volts; part of the power is transformed down to 123 volts for private lighting and power service, and part is converted in two sub-stations into direct current at 550 to 600 volts for traction and public arc lighting.

Nernst Lamp.—A great disadvantage of most Nernst lamps is the more or less complicated devices required for switching out the heating body after the electrolytic incandescent body has been heated up and has become a conductor. In a summary of new improvements of the Nernst lamp, in a recent issue of the "Elektrotechnischer Anzeiger," a simple arrangement devised by Menganini is described, which eliminates the necessity of switching out the heating body, as no current flows through it after the incandescent body has been lighted. This arrangement is based upon the principle of the Wheatstone bridge, as illustrated in Fig. 2, where *L* and *L* are incandescent bodies, *W* is the heating body, and *R* and *R* are resistances of such values that no current flows through *W* after the incandescent bodies have been lighted. When the incandescent bodies are glowing, *R* and *R* serve as the resistances which are always required in series with the incandescent bodies of Nernst lamps, on account of their negative temperature coefficient.

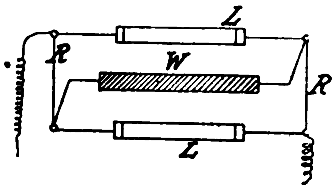


FIG. 2.

Poulsen's Telgraphone.—Mr. Vlademar Poulsen, a Danish engineer, has invented a recording telephone which is exhibited at the Paris Exposition and described in several French, German and British contemporaries. The physical principle upon which it is based is extremely simple. It is an application of the phenomenon known as remanent magnetism. A small electromagnet is connected in circuit with a telephone transmitter. Between the poles of the electromagnet a steel band is moved at a high uniform speed by any suitable means. The magnetic field through which this steel band is moving varies continuously, according to the current produced by the sounds spoken into the transmitter; by moving through the magnetic field, the steel band obtains a transversal magnetization, varying from point to point according to the magnetic field through which each point passes, thus becoming a magnetic record of the sounds spoken into the transmitter. This process is reversible; if the steel band is moved between the poles of the electromagnet and the latter connected in circuit with a telephone receiver, currents are induced in the circuit and the original sounds are reproduced by the telephone. It has been found by experiments that after a speech had been thus reproduced 1200 times by the same steel band, no weakening of the sounds could be observed. In a long article in "L'Industrie Electrique," Prof. Blondin points out that Poulsen's instrument is not merely a recording telephone but has many more applications; it may be used for strengthening telephonic signals, it can be employed as a telephonic relay, and—last but not least—by a special arrangement of Mr. P. O. Pedersen, who simply uses two electromagnets instead of one, it is possible to "print" two different records on the one steel band and to reproduce later each record independent of the other, which gives a simple means of duplex telephony.

"Distinctness" Photometer.—In a serial on the photometry of arc lamps for central stations in recent numbers of the London "Electrical Review," Mr. F. W. Carter describes an interesting "distinctness" photometer. The illumination due to two lights is considered to be equal when a meshwork of black lines on white ground can be distinguished equally well by either. The essential feature of the photometer is an addition which might be made to one or any form in which a comparison is made between the illumination of two areas, one of which is illuminated wholly by the arc lamp and the other wholly by the standard lamp; for instance, the Joly photometer. In Fig. 3 *A* and *A* are equal blocks of paraffin wax or of milk glass, separated from one another by a thin plate of metal foil, *B*; one block is illuminated by the arc and the other by the standard, and the effect is viewed from the front at *C*. To this front is attached a plate marked with a graduated mesh or other convenient pattern, as shown in Fig. 4. To use the photometer, seek the level at which the mesh becomes so fine as to begin to be indistinct and move the photometer until this level is the same on the two sides of the center line. The results obtained with this photometer are said to give at least the accuracy that the variable nature of the arc permits one to aspire to.

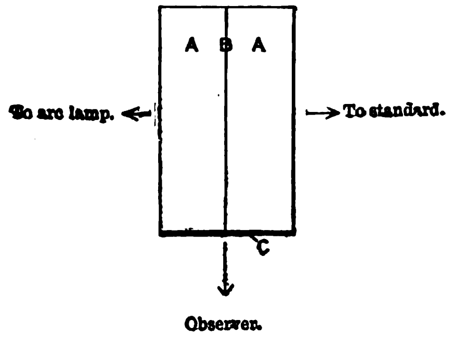


FIG. 3.

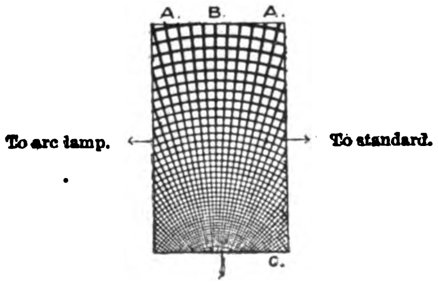


FIG. 4.

American Railway Practice.—A recent issue of the London "Electrical Engineer" contains a paper, read by Mr. Le Rossignol at the recent annual meeting of the British Municipal Electrical Association, in which, after some general remarks of comparison of the conditions in the United States and in Great Britain, he remarks that as economy in current generation is greatly influenced by the cost of labor in the station, central-station practice in America rightly tends to the introduction of very large steam-power units, but these are all of the open, slow-moving type, and so require a larger amount of attendance than would the same size units, if enclosed and provided with automatic lubrication, such as have been largely adopted in Great Britain. He says that overhead work in America does not compare at all with what is put up in Great Britain, either as to strength or neatness, but in many other traction matters the United States is ahead.

Utilizing the Energy Lost in Resistances.—In a recent issue of the "Elektrotechnischer Anzeiger" an anonymous writer suggests utilizing the energy lost in auxiliary resistances, such as those used for regulating the speed of motors, steadying arc lamps, etc. For instance, the resistance for regulating the speed of a fan motor may be switched in for quite a while, while the fan motor is running at less than full speed; in this case he suggests the use as auxiliary resistance of a low-voltage incandescent lamp, placed in a room not too far away from the motor. At its side he suggests placing another lamp to be supplied with current direct from the supply mains and arranging the connections so that as soon as the resistance lamp of the motor is switched out, the other lamp is automatically switched in, the circuits being such that the two lamps cannot be lighted at the same time.

Compound Exciter of Hutin and Leblanc.—In a recent issue of "L'Industrie Electrique," Mr. J. L. Routin gives a long description of a 600-kw. three-phase alternator exhibited by the firm of Grammont at the Paris Exposition. The special feature is the compound exciter, designed by Hutin and Leblanc, for automatically supplying the proper exciting current to the alternator, so that constant voltage is obtained, independent of the load and of the power factor. As shown in Fig. 5, it has a direct-current dynamo armature, *A*, in two different rotary magnetic fields, produced by the stators, *B* and *C*, like that generating the rotary field of an induction motor. The winding of the stator, *B*, is made of fine wire and connected across the terminals of the alternator as a shunt; the winding of the stator, *A*, is connected in series with the alternator armature. It is evident that by properly designing the two systems of stators, it is possible to obtain an exact method of compounding. The characteristic point of the invention of Hutin and Leblanc is the special arrangement by which they can take off direct current by means of fixed brushes from a direct-current armature acted upon by a rotary field. To make this more explicit, consider an ordinary bipolar direct-current dynamo with stationary field and brushes, and revolving armature; it would work in exactly the same way if the armature were stationary, and the field and brushes revolved at the same speed and in the same direction. Now imagine the connections of commutator and armature, which may be a simple Gramme ring, reversed with regard to a certain diameter, $x\ y$, as shown in Fig. 6, where the dotted lines are the ordinary connections and the straight lines the new reversed connections; then if $p\ q$ was the position of the brushes at a certain time with the ordinary connections and $p_1\ q_1$, the position at the next moment, then with reversed connections $p'\ q'$ is the position of the brushes and $p'_1\ q'_1$ at the next moment; that is, now the armature rests, the field rotates with a certain speed, the brushes rotate with the same speed, but in opposite direction; in a machine with 2 *n* (instead of 2) field poles it is necessary to reverse the connections with regard to *n* lines of symmetry. Further, if there are 2 *n* field poles it is not necessary to use 2 *n* brushes, but let the number of brushes be 2 *k*, then the machine will work as before, if the revolving speed of the brushes is *n*/*k* times that of the speed of the field. It is obvious that in order to take off direct current by means of brushes fixed in space, the speed of the exciter armature must be proportional to the frequency of the alternating current, and their ratio is determined by the number of poles and brushes of the exciter. Therefore a suitable gearing must be provided between the alternator and the exciter.

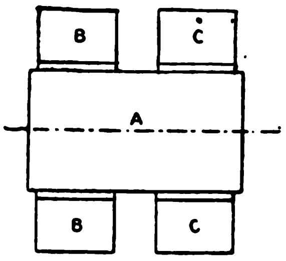


FIG. 5.

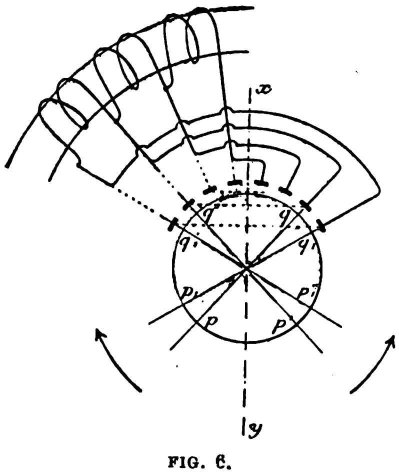
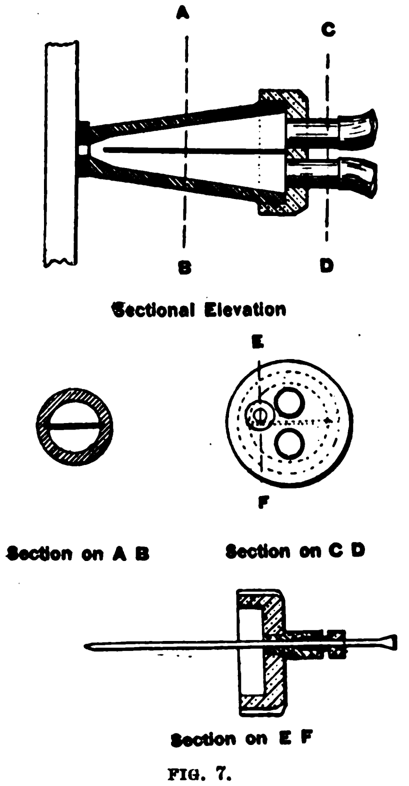


FIG. 6.

Electrolytic Drilling and Slotting of Metals.—Mr. Sherard Cowper-Coles describes in a recent number of the London "Electrical Review" successful experiments made to work out a practical electrolytic method of drilling and slotting holes in metals. The point of the metal, where the hole is to be drilled, is the anode. The electrolyte is rapidly circulated through a nozzle, the construction of which is plainly shown in Fig. 7. As will be easily understood, the electrolyte is moved round the baffle plate down the centre. A pointed rod, fitted in a gland, is so arranged as to be near the end of the baffle plate; this needle forms the cathode, on which the iron is deposited as a powder, due to the high current density, and is washed away by the rapidly circulating electrolyte. The end of the nozzle is fitted with a rubber washer which can be easily removed, and the shape and size of the hole to be drilled are determined by the shape and size of the rubber washer. Some of the best results for iron have been obtained with a solution of sulphuric acid, but good work has also been done with ordinary salt water.



Sectional Elevation

Section on A B

Section on C D

Section on E F

FIG. 7.

Revolving-Field System of Dial Signals.—A paper by Mr. F. Querengaesser in a recent issue of the "Elektrotechnische Zeitschrift" describes an interesting system of dial signals for battleships, for instance for transmitting orders from the bridge to the engine room; it comprises instruments of the General Electric Company of Berlin, and is called the "revolving-field system." It is operated by direct current and it is easily understood from the diagrams. In Fig. 8 *a* is a closed resistance, like a Gramme ring, which is supplied with direct current at two opposite points by means of the movable lever, *b b*; this is the transmitter. The line consists of three wires, *e, e, e,* which start from three symmetrically situated points, d_1, d_2, d_3, of the transmitter resistance and end in the three coils, f_1, f_2, f_3; the magnetic field produced by these coils determines the position of the magnetic needle, *g*; this is the receiver. To transmit a signal, the lever, *b b*, of the transmitter is moved; then the needle of the receiver moves in accordance. It was found, however, in practice that the instrument was not quite independent of variations of the e.m.f. of the source supplying the direct current; the needle of the receiver showed sometimes deviations from the correct position. This drawback is evaded in the arrangement adopted in the new instruments of this system. In the old instruments all parts of the closed transmitter resistance have a uniform resistance; in the new instruments this is not the case, but the resistance varies according to a certain law, indicated by the difference in the thickness of the lines of Fig. 9. Further, while the current is supplied to the resistance at two fixed opposite points, it is taken off at three movable points by means of the brushes, c_1, c_2, c_3, which are 120° apart.

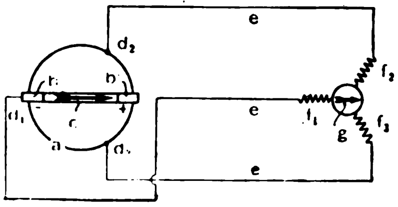


FIG. 8

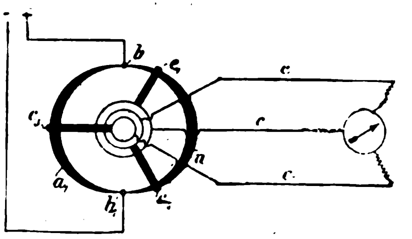


FIG. 9.

Some Recent Electrical Patents

Bus-Bar Wattmeters for Three-Wire Circuits.—The construction of Thomson recording watt-hour meters for measuring large amounts of power on three-wire systems is shown in the accompanying plan and elevation, Fig. 1. The meters for this purpose are made astatic, i. e., they are designed so that they are not influenced by any magnetic field set up by sources outside of the meter itself. This is essential as this type of meter contains no iron and works therefore with a very weak field, which is easily affected by the magnetic influence of the powerful currents in neighboring leads or bus bars. The astatic property is obtained by using two rotating armatures, the windings of which are connected in series with each other to one commutator, but in such a way as to set up opposite effects in the two armatures; that is to say, a coil in one armature is connected in series with a coil diametrically opposite it in the other armature; thus when current flows through the two armatures in series they are oppositely magnetized. For this reason any field set up by an outside influence through the two armatures gives one a torque in one direction and the other a neutralizing torque in the other direction. The current to be measured by such a meter is generally so heavy that a single bar passing close to but not necessarily around the armature, gives a sufficiently strong field. By running this bar between the two armatures of an astatic meter the lines of force around the bar set up a field in one direction above it, i. e., in one armature, and in the other direction below it, i. e., in the other armature. The armatures being oppositely magnetized, the two give a torque in the same direction and run properly in spite of their independence of stray fields. An astatic arrangement of the braking mechanism is also obtained by using two discs and two magnets oppositely polarized, one vertically above the other. If the instrument is designed for accurately averaging unequal outputs on the two sides of a three-wire circuit, two bars must be used, one connected in the positive and the other in the negative side of the circuit. These two bars are shown in the accompanying plan, one connected between the studs, A and D, and the other between the studs, B and C. The patent,

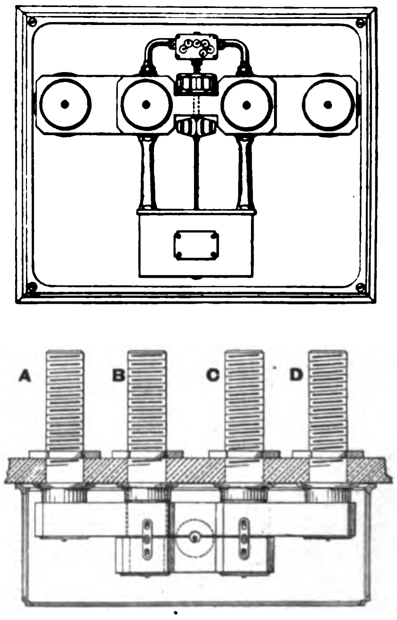


FIG. 1.—BUS-BAR WATTMETER.

which was taken out by Mr. W. H. Pratt of the General Electric Company, claims a means of adjusting the armature so that it may be equally affected by equal currents in the two bars. This adjustment is made by moving the shaft, G, laterally to a position nearer one or the other bars, until both have the same effect. Patent No. 649,707.

Terminals for Nernst Glowers.—Considerable difficulty has been experienced in making connections between the ends of the illuminator of a Nernst lamp and the leading-out wires, the character of the refractory material forming the illuminator being such as to make a permanent joint somewhat difficult to effect. It has been proposed to wind a fine platinum wire around a portion of each end of the illuminating rod and to cover this with a paste made of the same material as that of the illuminator, but this form of connection has not proven substantial. An improved method of making such connections is described in a patent recently issued to Mr. Marshall W. Hanks. The method devised by Mr. Hanks consists in applying to the ends of the illuminating rod beads or enlargements of chalk-like material which are baked in place on the ends of the rods by an oxyhydrogen flame. The leading-in wires are then attached by fusing them to the beads on the ends of the illuminator by means of some conducting alloy, such as copper-platinum, nickel-platinum, etc. It is stated that after sufficient heat has been applied to bake the bead any union made between the bead and the leading-in wire remains unbroken. Patent No. 652,609.

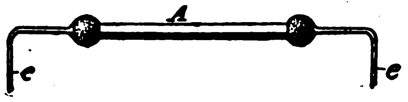


FIG. 2.—GLOWER TERMINALS.

Nernst Lamp Heater.—As is now well known, the ordinary Nernst lamp consists of a rod of refractory oxid, the resistance of which when cold is so high as to make it practically a non-conductor; when heated to a sufficient temperature the resistance falls and allows considerable volume of current to pass under ordinary electric pressures—in short, the material has a negative temperature coefficient with reference to its conductivity. Various methods have been proposed for obtaining and applying the initial heat necessary to make the glow rod pass the current. One of the simplest of these is described in a patent issued to Mr. H. N. Potter, and illustrated by Fig. 3. The illuminating rod, *A*, is surrounded by a spiral conductor, *B*, which constitutes the heater, the construction of which is unusual. The wire forming the heater is wound into a close helix around a talcite rod, which is formed by pressing plastic talcite through a small orifice. The speed with which the winding machine revolves about the orifice is so arranged with reference to the speed of the issuing thread of talcite that the convolutions of fine wire on the surface of the latter lie very close together. After being formed into shape the structure of the heater is baked hard. Patent No. 652,638.

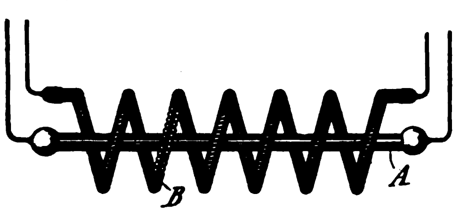


FIG. 3.—NERNST LAMP HEATER.

A Novel Connection for Synchronizing Lamps.—With synchronizing lamps or voltmeters connected up in the usual way there is no means of telling which of the two machines being synchronized is running the faster and which is running the slower, the lamps beating in the same manner whether machine A is running faster than machine B, or machine B faster than machine A. There is used in Germany a special connection of synchronizing lamps for indicating which machine is running the faster, this connection having been patented by Mr. C. J. A. Michalke, the American patent having been assigned to the Siemens & Halske Electric Company of America. The connection for three-phase machines is shown in Fig. 4. The two groups of windings in the upper part of the figure, indicate the two machines, one with terminals A′, B′ and C′, and the other with terminals A^2, B^2 and C^2, both connected to the main switch, D, by which they may be thrown in parallel with each other when synchronized. The letters, d, d^1 and d^2 signify the three synchronizing lamps, and e is a synchronizing voltmeter. It will be noted that lamp d is connected between terminal A′ of one machine and the corresponding terminal A^2 of the other machine, so that when dark it indicates that the machines are in the proper phase relation to be thrown together; d′ is not connected between corresponding terminals of the two machines, but is connected between phase B of one machine and phase C of the other, while d^2 is between C of one machine and B of the other. These lamps therefore are not extinguished at the same time that lamp d is, but beat in time with the difference of speed between the two machines, the beats of all three lamps being out of phase with each other. A careful analysis of the connections, not necessary here, shows that if these three lamps are arranged in triangular order the illumination of the lamps will travel around the triangle in one direction when machine No. 1 is running more slowly than No. 2, and in the other direction when machine No. 2 is running more slowly than No. 1. Thus when a fresh machine is to be thrown in to the bus bars it can readily be determined whether to speed it up or slow it down to bring it into synchronism. The patent describes many variations of this method for use with a single-phase or two-phase machines, with or without transformers. Patent No. 649,942.

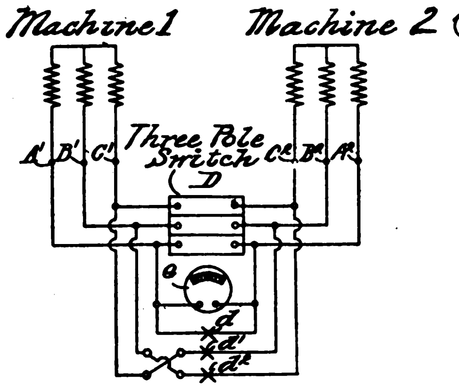


FIG. 4.—SYNCHRONIZER CONNECTIONS.

Igniting System for Nernst Lamps.—A system designed to facilitate the use of Nernst lamps for street illumination has been patented by Mr. A. J. Wurts and assigned to Mr. Geo. Westinghouse. This system is shown diagrammatically by Fig. 5, in which *a* represents the heating coils or strips which are connected in series and supplied from a step-down transformer, 14. This transformer is connected one leg to one side of the main circuit, 3, and the other leg to a separate and special wire, 4, which may be controlled from the station by the switch, 5. The glowers of the lamps are supplied through the transformer, 8, from the regular mains, 2 and 3, in the same manner as ordinary incandescent lamps. Patent No. 652,701.

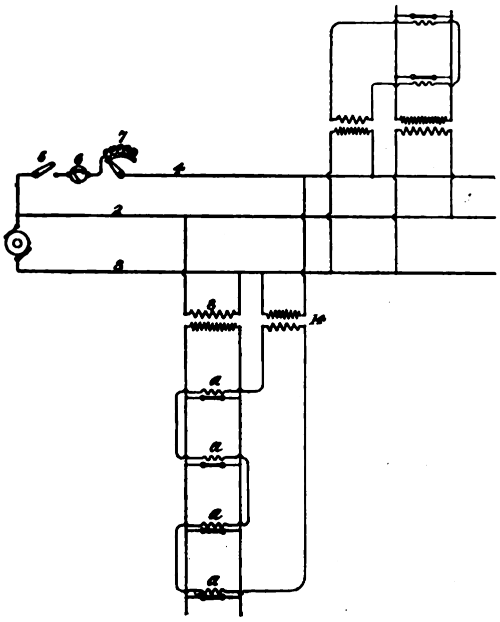


FIG. 5.—IGNITING SYSTEM.

Multiple-Glower Nernst Lamp.—Mr. Chas. A. Terry has patented the arrangement shown in Fig. 6, which consists of mounting two or more Nernst glowers in parallel with each other and connecting the whole group in series with a resistance, *d*, and an electromagnet which serves to cut out the heating coil, *e*, when any one of the illuminating rods has reached a conducting temperature. The patent is for the combination of two or more glowers in parallel and a current-restraining device in series with them, the object being to provide a means for continuing the illumination in case the glow rod which is in service should break. The operation as described in the patent is as follows: When the switch, *g*, is closed current flows through the heating coil, *e*, and heats the glowers. As soon as one of these becomes sufficiently hot to pass an appreciable amount of current the magnet cuts out the heating coil, leaving one glower alight. When the glower breaks, the magnet drops its armature and the heating coil starts up another glower. The particular glower which becomes incandescent is determined by the relative resistance of the several rods, the one having the lowest resistance being the first to become incandescent. No adequate explanation is offered as to why only one glower of the group becomes incandescent. Patent No. 652,494.

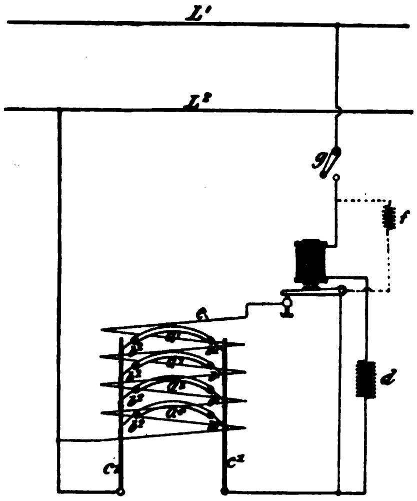


FIG. 6.—MULTIPLE GLOWERS.

NEW BOOK.

The Technic of Mechanical Drafting. By Charles Reinhardt. New York: The Engineering News Publishing Company. Cloth; 36 pages of text, 8x12 ins.; 62 illustrations, and 10 full-page plates. Price, $1.

This work is what it claims to be, a dissertation on the technic or workmanship of mechanical drafting, and not a treatise on the mathematical principles involved. The author begins with the ink and pens, then discusses the paper, and so on step by step, until the ground is thoroughly covered. The directions for making erasures on tracing cloth will doubtless be thankfully received by many draftsmen who have had trouble in this respect. The best idea of the contents of this book is obtained from the chapter headings, which are as follows: General Instructions; Outlining; Outline Shading; Section Lining; Curved Surface Shading; Shading of Inclined Surfaces; Map Drawing; Character and Finish. Under Curved Surface Shading are given some examples of how not to do it as well as the examples of how to do it, which is an excellent way to illustrate this point. The mechanical make-up of the book is excellent and the style is clear and concise. This edition has a neat cloth binding, but it is otherwise in the style of the author's book on draftsmen's alphabets and lettering. There is a table of contents, but in order to use it in finding anything in the book it is necessary to add six to the page number found in the table in order to know the number actually printed on the page sought.

NOTES.

A Bill to License Wiremen. — It is reported that a bill is to be presented to the Indiana Legislature, the provisions of which stipulate that persons installing electric wires shall be licensed before they can engage in this work; the object of the bill is to guard against the improper wiring of buildings.

Munificent Compensation. — According to an exchange, the salaries of electricians in the navy have been raised, chief electricians now being paid $60 per month, subordinates of the first class $50, those of the second class $40, and those of the third class $30! It would be interesting to know what the salaries previously were and why the positions continue to be filled. Is there no employment to be found in the tenth-class country central stations?

An Underground Cable Due to Spiders. —The Government of the Argentine Republic has determined to lay an underground cable 150 miles long between Buenos Ayres and Rosario in order to obtain reliable telegraphic service, which is impossible with overhead wires. Small spiders spin long webs which settle on the wires in such numbers as to form serious leaks as soon as they are moistened by dew or rain, the result being intolerable interruptions of the service.

The Danger of Celluloid Collars for Motormen. — A motorman on the Waukesha Electric Railway, Milwaukee, was investigating some trouble on his car when his celluloid collar came in contact with several of the connections; there was a flash and a ring of fire immediately encircled the motorman's neck, inflicting most painful and dangerous injuries. As a result of this accident, it is stated that President John I. Beggs has issued an order that motormen on electric lines shall not wear celluloid collars.

Cheap Electric Power in Canada. — Rates recently established for electric power at Ottawa, Canada, are probably the lowest on record. The E. B. Eddy Company has a contract with the Deschenes Electric Company for several thousand electrical horse-power at $15 per horse-power per year, and an offer was recently made by persons controlling the Little Chaudiere water power to a syndicate proposing to establish a cotton-mill enterprise, of 3000 electrical horse-power at $10 per horse-power per year.

Telephone Bureau of Information. — An idea which is new in telephone exchange practice and which should bring the originator substantial returns in the way of regular patronage has been adopted by the Cuyahoga Telephone Company, of Cleveland, Ohio. This consists of establishing a bureau of information for the benefit of subscribers who have occasion to inquire concerning market quotations, railway and steamboat time tables, baseball scores and other matters of the same class. A special operator has been appointed to whom all inquiries of this character will be referred.

Harnessing the Neckar.—A power house has lately been built at Marbach, Germany, for the utilization of the hydraulic energy of the Neckar. The plant develops 1100 horse-power; the prime movers are four turbines of 14 ft. 7 ins., placed side by side. The height of the fall varies from 8 to 10½ ft. Each turbine is direct-coupled to an 11,000-volt alternator. The electric power is transmitted to Stuttgart, a distance of 12½ miles, and thence by an overhead conductor to Prague, where a sub-station has been erected. From this place it is carried by two cables to Stockach, and to the main station at Marienstrasse.

Electrical Development in Siberia.—With the construction of the Trans-Siberian railway, now rapidly nearing completion, the towns in extreme Siberia will undergo a truly remarkable transformation. For example, it has been announced that the municipality of Vladivostok has decided to construct 18 miles or more of trolley lines, at the same time that its attention will be engaged with the construction of waterworks for the town, as well as the construction of a central station for supplying the inhabitants with electric lighting. American concerns, it is said, are largely interested in the work of thus transforming the wilds of Siberia.

Cement for Celluloid.—It is, of course, well known that, owing to the inflammable nature of celluloid, it is impossible to join by means of heat two pieces of this material. According to "La Nature" there is a cement which will permit of the broken pieces being repaired; the following is given as the process: A mixture is made of five parts of alcohol and four parts of ether (a mixture that can be easily kept in a glass jar, firmly corked); to join the two pieces, moisten the surface or edge of each with the mixture, repeating the moistening until the surface becomes softened. The two pieces are then pressed together and kept in this position for at least 24 hours.

International Association of Municipal Electricians. — The fifth annual meeting of this association will be held in Pittsburgh, September 25, 26 and 27, on which occasion the following papers will be read and discussed: "Benefits to be Derived from Our Association," by Capt. Wm. Brophy, Boston, Mass.; "Contact Points," by Frank C. Mason, Brooklyn, N. Y.; "Trials and Troubles of Instituting and Forcing Municipal Inspection and Control," by M. G. Canfield, Grand Rapids, Mich.; "Automatic Fire Alarm Systems," by Chas. Burger, Boston, Mass.; "Advantages and Disadvantages of Carrying High and Low Potential Conductors on the Same Poles," author's name not given. The headquarters will be at the Monongahela House and the sessions will be held in the banquet hall of this hotel, which has served as headquarters for various conventions for the past fifty years. In addition to the sessions, of which two will be held each day, there will be provided entertaining diversions in the way of trolley and steamboat excursions, carriage rides, theater parties, etc.

Against Fraudulent Use of Electricity.—The German Reichstag has just passed a law against the fraudulent use of electricity. Any person convicted of having taken a supply of power from any source using for the purpose a conductor the existence of which is unknown to the owners of the electrical source, is liable to imprisonment or a fine of 1500 marks. The loss of all civil rights is also inflicted on the convicted person. In case the fraud is committed with the intention to do injury to another party, the term of imprisonment is two years and the fine 1000 marks. If the phraseology is correctly quoted, the theft of electricity over a conductor known to the central station owner is not punishable.

A 44-Mile Interurban Electric Road Projected. — A company has been organized for the purpose of building an interurban electric railway from Grand Rapids, Mich., to Muskegon by way of Grand Haven. The line will be about 44 miles long and the estimated cost is from $1,230,000 to $1,500,000. The track will be laid along private right of way parallel to the country highways the whole distance, and large cars provided with 200-h.p. equipments will be used. The president of the new company is Mr. Jas. H. Hawks, who is also president of the Detroit, Ypsilanti & Ann Arbor Railway, which is one of the finest properties of the kind in the United States.

Bipolar Dynamos in England.—"Lightning's" reviewer of exchanges, who is always clever but who occasionally sacrifices accuracy to humor, recently gave vent to the following:

"The American Electrician declares that from the beginning the form of dynamo field magnets has been dictated purely by fashion, and designers have followed each other like sheep whenever a new type was introduced. Of these it enumerates four. The present fashion is still that of the circular yoke with radial poles. It has reigned longer than any of the previous forms and the American Electrician thinks it will be permanent, not so much because it happens to combine more advantages than any other but because 'the gamut of practical magnet shapes has been about run.' Considering the enormous preponderance of two-pole dynamos in this country it is humiliating to imagine what the smart set of fashionable American electricians must think of us."

The irony is exceedingly fine. So, likewise, is the anamorphosis which the writer sets up, calmly ignoring the rapidity with which the "enormous preponderance of two-pole dynamos" is yielding place to the prevailing American type—in not a few instances of American manufacture.

Automobile Exhibitions. — There promises to be considerable activity in automobile work this fall, judging by the exhibitions and races now proposed. There will be an international exhibition and race meet at the Washington Park Club Grounds, Chicago, beginning September 18 and lasting five days; $10,000 in cash prizes and trophies will be distributed. Another exposition, the programme of which includes races, will be held at the Interstate Fair, at Trenton, N. J., September 24 to 28 inclusive. At Madison Square Garden, November 3 to 10 inclusive, the Automobile Club of America will give an exhibition, a feature of which will be contests in speed and skill. From November 14 to 24 an automobile show will be held at Grand Central Palace, New York City, under the management of Mr. M. Nathan. It is stated that about one-half of the total exhibition space has already been engaged and the prospect for a successful show is extremely good.

Subways Proposed for Chicago. — John M. Roach, president of the Chicago Union Traction Company, has submitted a plan to the Street Railway Commission for down-town subway terminals for all the traction companies. The plan provides for 12 miles of subway, including six loops and a tunnel under the river at Dearborn Street. The bottom of the subway is to be 30 ft. below the surface of the street. Wire conduits and water mains are to be built in the subway, not below it. Immediately below the sidewalk it is proposed to build four conduits 6½ ft. high and 5½ ft. wide for telephone and telegraph wires, Edison mains, and city wires and pneumatic tubes. A 30-in. plate girder will separate these conduits from the car subway below. Two tunnels are to be provided where the cars go in opposite directions, the two being separated by a 3-ft. wall. Stations are to be provided at intervals along the route and the passenger platform will be one foot higher than the track.

Canadian Electrical Association.—This association held its tenth convention in the City Hall, at Kingston, Ont., August 29, 30, and 31. The convention was a most successful one, the papers being of a particularly interesting and timely character. The titles and authors of the papers were as follows: "The Use of the Dynamo and the Storage Battery in Telegraph Offices," by W. J. Camp; "Utilizing the Available Central-Station Capacity," by Prof. R. B. Owens; "Power Factor as Affecting Operation and Investment, with special reference to Induction Motors and Enclosed Arc-Lamps," by F. H. Leonard, Jr.; "Conditions Affecting the Wave Form of Alternators," by Prof. L. A. Herdt, "Rotary Converters," by J. Gordon Grier and J. C. Hyde; "Maximum and Minimum Power Requirements on the Quebec Railway System," by Mr. Blair. On the evening of August 29 those in attendance at the convention enjoyed a complimentary search-light excursion among the Thousand Islands, tendered by the mayor and citizens of Kingston. On the evening of August 30 the usual annual banquet was held and on the last evening of the convention a spectacular band concert was given, introducing a musical fantaisie of the battle of Paardeberg, with electrical effects and fireworks.

Elongation of Soft Iron Due to Magnetism.—In a recent number of The Physical Review, Prof. Louis W. Austin, of the University of Wisconsin, presents the results of some interesting experiments, made with a view to determining the elongating effect of magnetization upon soft iron. The tests were made with a bundle of 10 Swedish iron wires 27½ cm. (10.827 ins.) long and 1.4 mm. (.055 in.) in diameter, in a magnetizing coil of 288 turns distributed over 24 cm. (9.4488 ins.) of the core; both direct and alternating current were tried. With direct current, the maximum elongation of the core was 0.000415 per cent of its length, in a field of 70—75 gausses intensity. With alternating current at 60 cycles the maximum elongation was 0.000341 per cent in a field of 75—80 gausses; and at 120 cycles, it was 0.00031 per cent in a field of 70—75 gausses. With stronger and weaker fields the elongation was less, indicating a molecular influence other than magnetization and hysteresis.

Tests of Street Car Brakes. — The Board of Railway Commissioners of New York City has issued an interesting report on competitive tests of street car brakes which it had made last year. The tests were exhaustive and the report is correspondingly elaborate. Five classes of brakes were tested, to-wit: The Magann, Christensen, Standard and Reyburn air brakes; the Electric Selector & Signal, General Electric, Columbia and Price & Darling electric brakes; Sterling, Vogel and Sauvage hand-power brakes; Price (Peckham) and Brill friction brakes, and the Devlin track and wheel brake. After a consideration of all the various features of the tests in the light of the requirements of actual service the board gave the several brakes the following final standing in the order of their respective merit: (1) Electric Selector & Signal electric brake; (2) the Price (Peckham M. T. & W. Co.) friction brake; (3) Sterling hand-power brake; (4) the Magann air brake; (5) the Vogel hand-power brake; (6) the Devlin track and wheel brake; (7) the Brill friction brake; (8) the Sauvage hand-power brake; (9) the Standard air brake; (10) the Christensen air brake; (11) the General Electric electric brake; (12) the Reyburn air brake; (13) the Columbia electric brake; (14) Price, Darling & Co. electric brake. The tests were made on the Lexington Avenue branch of the Metropolitan Street Railway Company's system.

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Transformer Core Deterioration.

The "ageing" of transformer cores has become a familiar phenomenon and in many cases has caused a serious increase in the fixed losses of alternating-current stations. The very latest types of transformer contain iron that has a very low ageing coefficient, but there are hundreds of stations operating transformers that were built before the peculiar characteristic referred to had received proper attention. A simple remedy for such stations is to systematically take in its transformers, a few at a time, dismantle them, and anneal the core iron. There have been cases where this policy has resulted in a yearly saving of 100 to 200 times the cost of annealing.

◆

The Nernst Lamp and Street Lighting.

The Patent Office records for the past few weeks indicate that there has been notable activity lately in the Nernst lamp field, and a welcome feature of these records is that almost all of the devices and systems patented are practical and meritorious in general character, the patentees being men of established ability. These facts incite speculation upon the possibilities of this form of lamp and the probability of its commercial development. Thus far no definite and reliable data have been made public concerning the best voltage to be employed and the relation between the size of a "glower" rod and its candle-power, so that it apparently has yet to be determined whether or not this type of lamp is well adapted to the supersession of the filament type of incandescent lamp or to interior work where limited voltages only are allowed; only the vague statement has been made that the Nernst lamp works best at 200 to 600 volts, which is almost meaningless.

But all indications thus far are favorable to its ultimate employment for street lighting, and in view of Mr. H. H. Wait's recent comparison of incandescent and arc lamps for such service, one is encouraged to expect an enormous simplification of the street lighting question as one result of the development of the Nernst lamp. That such development along commercial lines must come there can be no doubt, and should the efficiency of one watt per candle be realized, the probability of which has been claimed, it would appear to be a foregone conclusion that arc lamps are doomed. With even an efficiency of 1½ watts per candle, and reliable lamps, arc lamps will not enter largely into the problem of street lighting, because of the greater simplicity of the Nernst lamp outfit and the immense saving in attendance, not to mention the vastly superior distribution of light, which its adoption would entail.

◆

Generating Units for Small Stations.

When the output of a central station is 1000 kilowatts or more, it is a simple matter to make the generating units all of one size, and it is not difficult to determine the most desirable size in the light of the operating conditions. Quite a different problem is presented, however, when the plant is so small that a single generating unit capable of carrying the whole maximum load is none too large for ordinarily efficient performance. In such a case the temptation to sacrifice interchangeability to flexibility is extreme; the natural impulse is to put in one unit to supply the load during what may be termed the period of "reasonable" load, and a much smaller unit to take care of the peak and to carry alone the minimum load. Such an arrangement is alluringly flexible and convenient—at the switchboard—but it is unreliable unless a complete set of duplicate vulnerable parts be kept on hand and in operative condition.

Even with this convenient arrangement of the generating plant, one of the units would necessarily operate at abnormally low efficiency during a considerable part of its run. If there be a great difference in the sizes of the two units, the larger one must operate at this low efficiency whenever the load is just too large for the smaller unit to carry it; if there be not a great difference in sizes, then the smaller unit will show wretched economy during the minimum-load period. So that in fixing the ratio between the two generating units one must choose between the two horns of an awkward inefficiency dilemma; this is anything but easy in advance of the existence of the conditions which determine the extent of the inefficiency on either side of the dilemma.

Hence, it would seem that the contention in favor of equal units for small stations, which Mr. Mather advances in another column, is not nearly so extravagant as it might at first blush appear. The only object in employing units of different sizes is to be able to operate the plant at fair economy throughout the greater part of the total run. Supposing the minimum load to be one-fourth of the ordinary load, which it seldom is, the smaller unit would be one-fourth the size of the larger, and the latter, consequently, would have to run under a little better than quarter-load for some time before it could be relieved by the smaller unit. Under the same conditions but with two generating units of the same size one of them would never carry less than half-load. Moreover, it is a physical impossibility to predetermine to a nicety what the vagaries of the load curve will be like; consequently, it would seem infinitely more practical to put in units of equal size than to waste time in hair-splitting effort to grade the plant according to what the load curve ought to be—and rarely if ever is.

Railway Motors on Grade.

The old saw to the effect that appearances are deceptive—in Gilbertian mode, "Things are seldom what they seem,"—was never more positively demonstrated than in the performance of ordinary series-wound street railway motors on a good steep grade. Everyone at all interested in railway work, and many a person with no particular interest in that or other kinds of work, has noticed that some cars crawl up a bad grade in a hesitating sort of way as though a collapse were imminent, whereas others bowl merrily up in a sort of semi-impudent style as though making effort to show contempt for the extra work involved.

The most natural impression created by a visual comparison of two such performances is that in the first case the motors are overloaded and in the other they have ample reserve ability. As a matter of fact, the opposite is the true state of affairs. The motors that ascend the grade slowly do so because the magnetic flux through their armatures has been increased considerably by the increase in field ampere-turns due to the heavier current flow, which means that under normal conditions the magnetic circuits of these motors are not worked above the knee of the magnetization curve. The motors which maintain a high rate of speed on grade do so because their field cores are already saturated and the increase in current flow through the windings does not produce a corresponding increase in magnetic flux.

Without a little analytical consideration the foregoing statements may not be of particular interest. What they imply, however, is that the motors which ascend a grade at a brisk speed do so at the expense of excessive heating and have, therefore, no reserve ability, as a rule; the slower motors, on the other hand, are not so liable to over-heat, and although their gait may inspire apprehension by reason of its seeming uncertainty, the fact is that they have great reserve power and are capable of doing work that would in all probability reduce the windings of the faster machines to scrap. The explanation of this is that the torque is proportional to the product of magnetic flux and armature current; consequently, the slow motors, in which the magnetic lines of force increase somewhat proportionately to the current in the field windings, require less current to exert a given torque than the faster machines, which must depend almost solely upon the increase in armature current for any increase in torque beyond the normal. These observations are based, of course, upon approximately equal resistances in the circuits of the two motors, and similar radiating surfaces in both cases.

Storage Batteries for Small Stations.

Much of the vexation of laying out the equipment of a small central station may be eliminated by including storage batteries in one's considerations. A problem most frequently met in practice is the case of the station of such a size that the load during the greater part of the run is so small that a generating outfit of the proper size to take care of it would be impractically small or the attendance required is not justified by the size of the load. There are many such stations, and many others in which both of these conditions obtain. Here it is a question of putting in a storage battery or giving service only during the period of reasonable load. An amount of patronage during the period of insignificant load which would not justify the operation of a small generating equipment, with its necessary attendance, might be sufficient to warrant using a storage battery, charged and attended to during the normal running hours and left alone during the remainder of the day or night. It would depend on the advisability of supplying continuous service, in consideration not only of the direct income from the small load, but of the prestige gained with the public and the municipal authorities, which has a high commercial value.

Take for example, a plant to supply an incandescent load of 100 kilowatts maximum; two 75-h.p. units will be sufficient. It is fair to assume that by 11 o'clock the load will have dropped to about 15 kilowatts, and that from that hour until daylight it will average about 60 kilowatt-hours. A 20-h.p. generating equipment will take care of the load after 11 o'clock, but fancy the result of operating such a unit, or one of the 75-h.p. units on such a load. A battery plant to take care of the supplementary load must have a discharge capacity of about 75 kilowatt-hours to be on the safe side, and a discharge period of eight hours. Such a battery with its equipment will cost about $3,000. This battery connected across the bus-bars from starting-up time until it is charged will enable the generating plant to run at maximum efficiency, reducing the cost of coal per unit of output during the full-load period as well as the supplementary period.

Assuming an operating efficiency of 60 per cent for the battery and a coal consumption of four pounds per delivered kilowatt-hour for the generating plant, the supplementary service supplied by the battery will require 63 tons of coal per annum, and the interest and depreciation, at 15 per cent, will be $450. If the 75-h.p. generating unit were run all night for the supplementary load of 60 kilowatt-hours, the extra coal consumption, as compared with shutting down at 11 o'clock, will be about 115 tons and the extra help may cost anywhere from $400 to $720 a year. Putting the cost of extra help as equal to the interest and depreciation on the battery, there will be a saving of about 50 tons of coal a year with the battery equipment, besides more stable service and less depreciation of the generating equipment due to the shorter run.

The great drawback to the use of storage batteries in small stations, however, is the extreme difficulty of obtaining the conscientious and intelligent care which is absolutely necessary to the economical and reliable performance of any accumulator plant. In the first place, it is absolutely essential that all of the cells shall be charged to the same degree; futhermore, that the electrolyte in all of them shall be of precisely the same specific gravity. Both of these conditions require considerable and judicious "nursing," whereas in almost all small plants the idea prevails that any sort of treatment, or none at all, is good enough for a battery equipment.

DESIGN FOR A THREE HORSE-POWER MOTOR.

BY CECIL P. POOLE.

The motor design which forms the subject of this article has been prepared with a view to simplifying the work as far as possible without sacrificing the efficiency of the machine, and also without making it unduly heavy. The field magnet consists of a cast-iron frame into which are set wrought-iron magnet cores having cast-iron pole pieces, as shown in the semi-cross-section, Fig. 1. The cast-iron ring is preferably made in a single piece and the wrought-iron cores are turned to a very slight taper and drawn into holes in the yoke ring by means of a bolt and heavy washer from the outside. Unless the builder has excellent machine-shop facilities, however, and is an expert machinist, this construction will be found rather difficult, as it is necessary to have a perfect fit between the taper of the magnet core and that of the hole in which it is seated.

As an alternative the magnet frame can be cast in two pieces, the division being along the line, X, Fig. 2. If the motor is built in this way, each half must be chucked and the joint faced off fairly smooth, although it is not necessary to have a perfect joint, as no magnetic lines of force cross the break. After truing up the abutting faces of each half of the magnet ring the two halves should be clamped together with 1/32 in. of cardboard in between them and four straight holes bored for the reception of the field-magnet cores. A field-magnet core is shown by Fig. 3. The cast-iron pole-pieces must be accurately fitted to the ends of the cores and pinned permanently in place with iron pins.

The magnet ring and pole-pieces should be of the best grade of pig iron obtainable. The magnet cores should be made of Norway wrought iron. The corners of the pole-pieces should be heavily rounded so that no sharp edges are left. The length of the pole-piece parallel with the shaft is the same as its width at right angles to this dimension. The outside diameter of the magnet ring is 20⅛ ins. The extreme breadth of the ring parallel with the shaft is 8 ins. The other dimensions are as below:

	Inches.
A—Bore of armature chamber	8
B—Axial length of pole-face	3¾
C—Width of pole-piece, tip to tip, in a straight line	3¾
D—Radius to which pedestal seat is cut	8½
E—Thickness of yoke ring	1½
F—Distance betweeen ribs	7
G—Width of plane surface back of magnet coil	4½
H—Height, base line to armature center	12
O—Axial length of pedestal seat	4
P—Straight-line width of pedestal (width of pedestal seat is the same)	7
Q—Length of pedestal foot, commutator side	7

The dimensions of the magnet core (Fig. 3) are as follows:

	At		
	y	m	p
Diameter, ins.	2½	2¾	2⅛
Length, ins.	2	3	1¼

Fig. 2 is an edge view of the field-magnet frame, including one journal pedestal shown in perspective and the other in cross-section. After fitting the magnet cores into place in the ring, the pole-pieces should be bored and the pedestal seats cut, at one setting of the frame. Fig. 4 is a cross-section of the armature core, showing the details of construction. The discs are mounted on a cast-iron drum, which is provided with a flange head and a hub, J, at one end, the other end being open. The discs are clamped in place by a cast-iron ring which is provided with a hub, I, similar to that at the other end of the drum, and drawn to place by means of six ¼-in. bolts passing through holes in the clamping ring and tapping into the end wall of the cast-iron drum. The center lines of two of these bolts are indicated at b, b. The cast-iron drum should have a key-seat cut in it so that the discs may be positively driven.

Both the hub on the end of the drum and that on the clamping ring should be keyed to the shaft so that here will be no opportunity for displacement. At each end of the core structure a disc of fiber 1/16 in. thick should be provided, as indicated by the heavy black lines in the engraving. These discs must be toothed exactly like the core discs so that the ends of the magnetic core will be entirely covered. The iron core discs are 7¾ ins. in diameter, with a central hole 4¾ ins. in diameter, and 47 slots ¼ in. wide and ⅝ in. deep; the slots have parallel sides. The discs must be of the best grade of charcoal iron, ¼ in. thick. The dimensions of the armature core structure are as follows:

	Inches.
I—Length of hub clear through	2⅛
Bore of this hub	1⅛
J—Length of hub clear through	2
Bore of this hub	1
K—Diameter of hubs	2¼
L—Internal diameter of core drum	4
M—Outer diameter of core drum	4¾
N—Diameter of flange and clamping ring	6¼
Thickness of flange and clamping ring	⅝

The two journal pedestals are exactly alike and made of ordinary cast iron. The base must be turned accurately to conform to the circle to which the pedestal seat on the magnet frame is machined. The standard, or pedestal, is an open frame of ½-in. metal; the box is of the ring-oiling type, with a single ring hung exactly midway of the journal. Fig. 5 is a transverse cross-section of the pedestal and box. The box is bushed; the bushing may consist of a brass casting turned to shape, or it may be made by babbitting a piece of thin brass tubing, the outer diameter of which is a snug fit in the box. The oil slot across the center of the box must be provided with a suitable covering

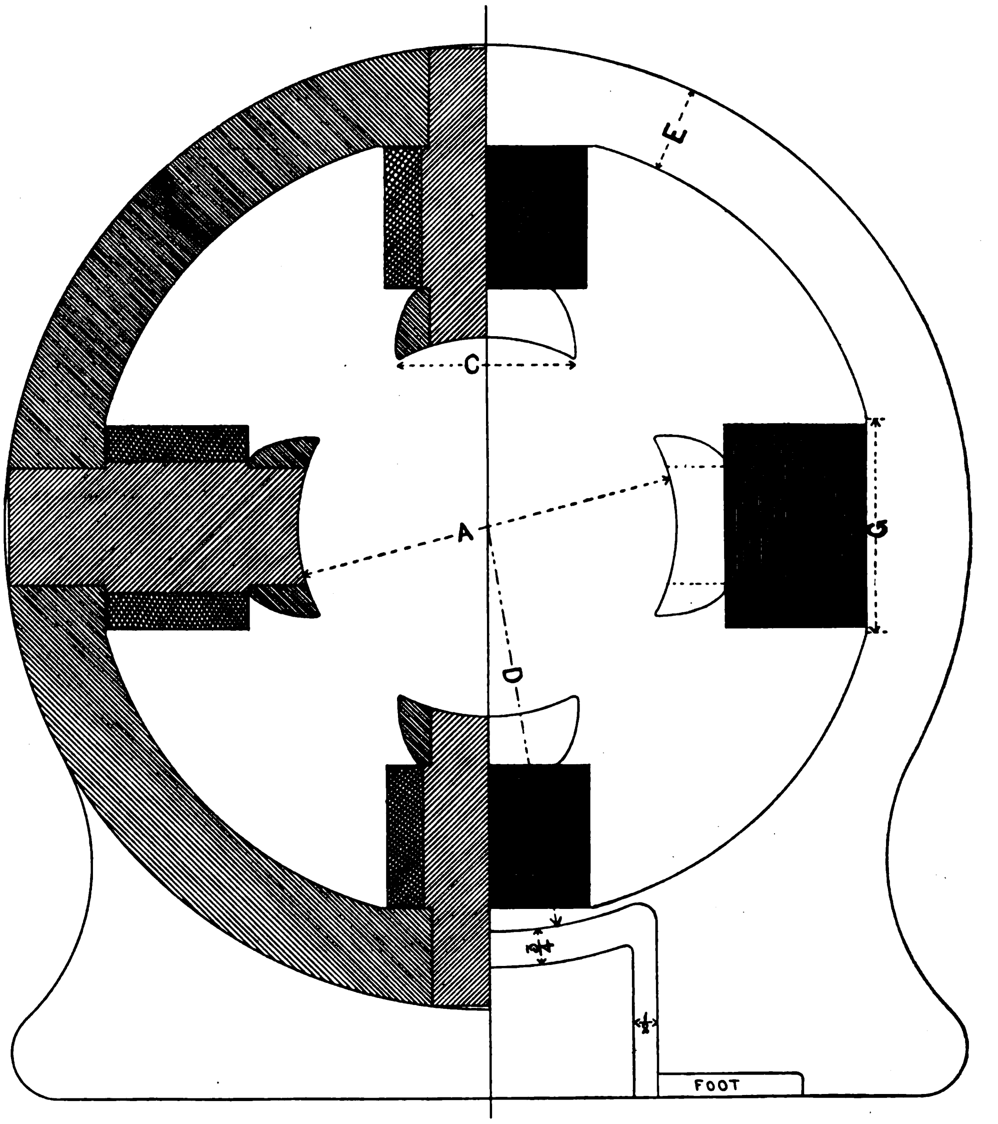


FIG. 1.—END ELEVATION OF MAGNET FRAME; SEMI CROSS-SECTION.

to exclude dust. Each pedestal should be bolted to the magnet frame with two ⅝-in. cap screws. The pedestal and box measurements are as below:

	Inches.
P—Widest part of standard	7
R—Axial length of oil well	2¾
S—Inner length of oil well	2
T—Inner width of oil well	3
t—Radius line to indicate origin of circle	1⅛
U—Outside diameter of box	2¼
V—Inside diameter of box	1½
W—Outside length of box	4
Y—Length of bushing	3¼
Bore of bushing	1
Z—Projection of box beyond oil well wall	15/16
Diameter of oil ring	2¼
Bore of oil ring	1⅞
Width of oil ring	⅜

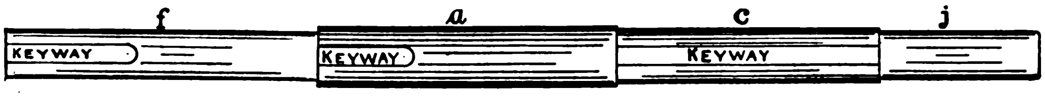


FIG. 6.—THE ARMATURE SHAFT.

A bearing must be turned on the outside of the inner end of the pedestal on the commutator side of the machine, as indicated in Fig. 2, to accommodate the brush-holder yoke, which may be copied from any of the standard makes. Only two sets of brushes are required, each comprising two carbon brushes ⅜ in. thick and 1⅛ ins. wide; the two sets must touch the commutator exactly 90° (11¾ segments) apart, center to center. The commutator must have 47 segments, and must measure 3 ins. along the shaft, extreme length. The commutator core must be bored to fit the portion, c, of the shaft, and key-seated to correspond. The diameter of the barrel should be not less than 4 ins., and the diameter measured at the connecting lugs must not exceed 6⅛ ins. The brush surface, measured parallel with the shaft, must be 2⅛ ins. long. It will be best to buy the commutator complete from one of the several makers of this class of apparatus.

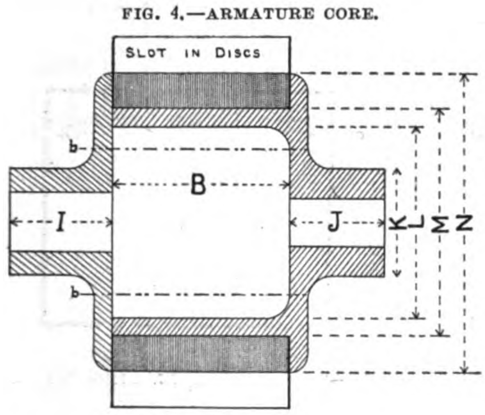


FIG. 4.—ARMATURE CORE.

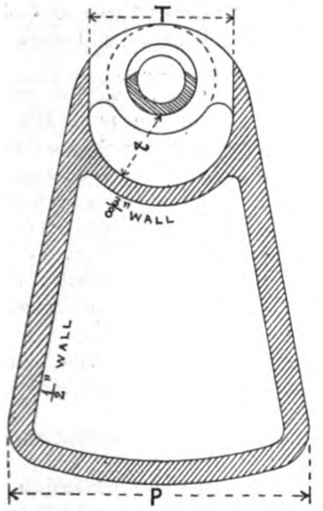


FIG. 5.—CROSS-SECTION OF A PEDESTAL AND BOX.

FIG. 3.—MAGNET CORE.

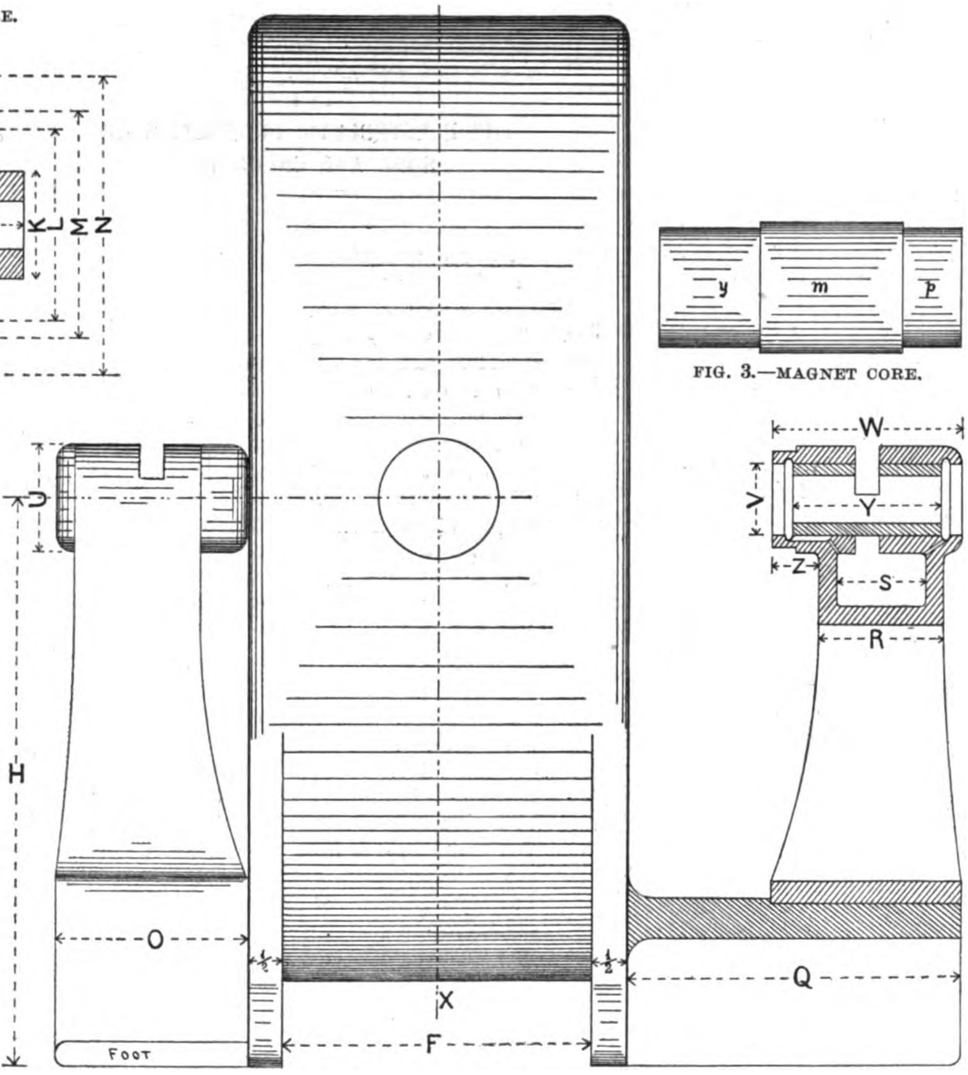


FIG. 2.—EDGE VIEW OF MAGNET FRAME AND SECTION THROUGH A PEDESTAL AND BOX.

Fig. 6 is the armature shaft. The key-seats are all ⅜ wide and 3/16 deep. The dimensions of the shaft are below:

	At				Total
	f	a	c	j	Lgth.
Diameter, ins.	1	1¼	1⅛	1	
Length, ins.	6 7/16	6 3/16	5 7/16	3 5/16	21⅜

The field-magnet coils may be wound directly on the cores or on bobbins made of thin vulcanized fiber. If they are wound directly on the cores, the latter must be wrapped first with three layers of unbleached cottons and painted with shellac varnish, two circular coil heads of hard fiber being first fitted to the large part of each core. The coils consist of No. 22 single cotton-covered wire, wound to a depth of ¾ in., exactly. The exact number of turns is immaterial, except that all four coils must contain the same number of turns, and as many turns should be put on as can be got in the space available. With careful winding, the builder should get 2565 turns in each coil. For a 230-volt motor use No. 25 double cotton-covered wire, wound to the depth specified. Should the reader prefer to wind the coils in bobbins, the magnet core need not be wrapped, of course. After each coil is completed, secure the outer end and cover the outside layer with unbleached cottons two layers deep, heavily varnished. Fig. 7 indicates how the field coils should be connected up.

The armature coils are of No. 13 wire, each coil containing eight turns. The winding must be two wires wide and four layers deep, per coil, so that when the coils are in place there will be 16 wires in each slot—two wide and eight deep. There are 47 coils, connected up wave-fashion. In winding the coils it will be advisable to bend a hook in each starting end and leave the final ends straight. The armature coils must be wound in a former so that the outline of the opening through each coil is a square measuring 4¾ ins. on each side. The ends should lead out from two corners, and each coil must be wrapped carefully and firmly with two layers of German linen tape, each layer being painted with shellac varnish. The slots in the armature core should be provided with troughs of press board 1/64 in. thick.

Put the coils on the armature all the same way—bent ends to the left and straight ends to the right, facing the commutator. There should be 12 teeth between the two slots in which any given coil is placed, and there must be 22 commutator segments between the two to which the terminals of any given coil are connected, as indicated by Fig. 8. It will be found best to first put on 12 coils in regular right-handed rotation, pressing the ends down closely where they lap, and slipping a bit of thin oiled paper between the crossings. This will put one layer of coils in 24 of the slots. Then put coils in the 23 vacant slots in the same fashion; there will then be 40 half filled slots and one filled.

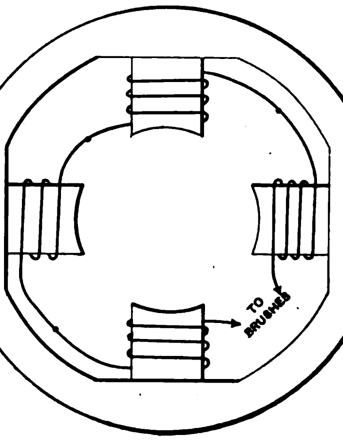


FIG. 7.—FIELD CONNECTIONS.

Continue the second layer of coils right along from the 24th coil, following the same plan as before. At the finish, there will be a bent end and a straight end projecting from each slot. Carry the bent ends 11 or 12 segments to the left, around the commutator, and put them all in the segment slots. Then take any one of the straight ends, find the bent end which is the other terminal of its coil, and connect the straight end, as shown in Fig. 8, with 22 segments between it and its mate. The other straight ends may be put in in regular order without tracing, if the coils have been put on the core properly and the bent ends in the commutator lugs in strict sequence.

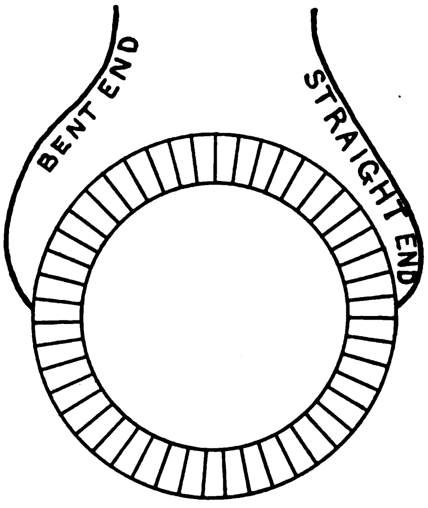


FIG. 8.

If it is desired to build the machine for 230 volts, wind the armature with No. 16 double cotton-covered wire, putting 15 turns in each coil—three wide and five deep—so that each slot will contain 30 wires, 3 wide and 10 deep. The principal technical data for the 115-volt machine are given below:

Revolutions per minute	1320
Armature resistance, warm	0.4
Armature current, normal	22
Armature and brush drop, volts, about	10
Per cent regulation, about	9%
Flux density in armature core and teeth, per sq. in.	75,000
Flux density in air gap	29,300
Flux density in magnet cores	93,000
Flux density in magnet yoke	24,000
Leakage coefficient	1.25
Resistance of field winding, ohms	169
Exciting current, amperes	0.68
Copper loss in field, watts	78.2
Copper loss in armature, watts	194
Core loss in armature, watts	46
Approximate efficiency, allowing 5 per cent for friction and windage, per cent	82

The starting box should be purchased from any of the standard rheostat builders; a satisfactory home-made one of this size is rarely produced.

* * *

THE ELECTROLYTIC PRODUCTION OF SODA AND CHLORINE.

BY JAMES F. HOBART.

After noting the several cells described in the preceding paper, it would seem that, according to theory, a form of cell like that shown by Fig. 13 would be desirable. There, a single tank is separated into two parts by a porous diaphragm, shown by the double section lining, each part of the cell being fitted with supply pipes for receiving the salt solution, and other pipes for the escape of the ions. The supply pipes marked NaCl are connected with some suitable source of supply, so that an equal level may at all times be maintained in both tanks, say at the dotted line.

The pipe marked Cl is to remove the chlorine gas as fast as it is liberated. The pipe Na_2O is where the caustic soda solution is drawn off as fast as it becomes saturated to a given degree of strength. A pipe at H permits the escape of what hydrogen may be formed in the soda cell. The diaphragm is made up of porous clay, asbestos, or any other suitable material. The electrodes are of carbon and iron, the carbon being positive. The exposed surface of the anode is the same as in Fig. 9 (August article), viz.: 180 sq. ins., but as only one side of the carbon plate in Fig. 13 is active the plate must be larger than that in Fig. 9, where two sides of the plate and both edges are exposed to electrolytic action. The plate in Fig. 13 must therefore measure 10 x 18 or 9 x 20 ins.

In Fig. 13, it is possible to put the anode and cathode very close to each other and to the diaphragm. Indeed, all the space necessary between them is enough to secure circulation of the electrolyte and to prevent the bubbles of gas (both chlorine and hydrogen) on both plates from gathering between the plates and the diaphragm. If the bubbles are allowed to accumulate, the resistance of the cell will be greatly increased, and its efficiency correspondingly decreased. Hydrogen and chlorine are both very poor conductors of electricity, and a collection of bubbles one-half inch thick between the two plates will increase the electrical resistance very greatly.

Not less than one-half inch of space should be allowed between the electrodes and the diaphragm unless means are provided (such as a pump) for keeping up a circulation of the electrolyte and dispersing the gas bubbles. Assuming the diaphragm to be one-fourth of an inch thick and of excellent conductivity, it is fair to estimate that its resistance is equal to one-half inch of saturated solution. With one-half inch of solution on each side of the diaphragm, the total resistance through which current must be forced is equal to that of 1½ ins. of electrolyte, or just one-half the thickness in the single fluid cell described in the previous paper.

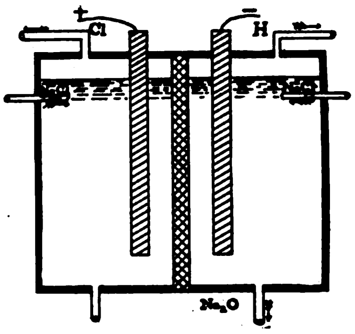


FIG. 13.—THEORETICAL ELECTROLYTIC CELL.

The resistance of that cell was 0.06 ohm; so that the resistance of the cell shown by Fig. 13 will be 0.03 ohm.

(In the August article, near the bottom of the second column on page 404, the statements relative to the resistance of an electrolytic cell should have read thus:

"To be on the safe side it will be estimated that this 'back pressure' (counter e.m.f.) is 2 volts. As it will require 2 volts extra in the current to neutralize it we simply add 2 to the e.m.f. required at the terminals of the cell.

"The entire resistance of the electrolytic cell illustrated by Fig. 9 may then be taken at $0.06 + \frac{2}{C}$ ohms, so that the impressed e.m.f. required for operation will be $.06C + 2$ volts. The superficial area," etc., etc.)

So far, this form of cell seems to have many good qualities. It is simple; the process may be continuous, owing to the supply and delivery pipes; and the ohmic resistance is small. This cell, however, has very serious faults. The carbon plate is large and will prove very hard to keep in shape, as stated in the last paper. Chlorine is not supposed to affect carbon, but it does, or the electric current acting in concert with the chlorine and other elements, causes the carbon to disintegrate; hence its failure is only a question of time and amount of use.

The diaphragm also suffers. It not only tends to go to pieces, but the pores fill up and its conductivity decreases. The diaphragm shown in Fig. 13 is large and very thin, only one-fourth of an inch thick. To keep this large plate from bending either way one-half of an inch is impossible. For these reasons it is not practicable to use the diaphragm shown in Fig. 13, but some form like that shown by Fig. 14 may be substituted. Here the diaphragm is circular, like the porous cup in a Leclanche battery. The anode must, therefore, be rolled up from a flat to a circular section and put inside of the diaphragm. Although diaphragms made in this form are practicable they fail very quickly, because they are subjected to disintegrating causes and go to pieces in a short time in a manner much similar to the way in which the flat diaphragms fail. The cylindrical diaphragm is, therefore, better than the plate form only in its freedom from buckling. The substance will disintegrate, flake and scale off just the same as with the plate form, but it cannot bend out of place and come in contact with some other part of the apparatus.

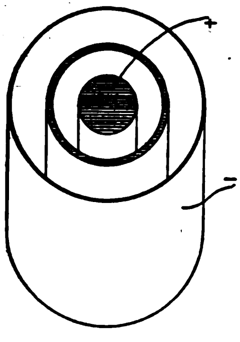


FIG. 14.—CIRCULAR FORM OF ANODE AND DIAPHRAGM.

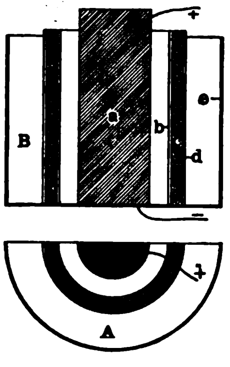


FIG. 15.—ASBESTOS DIAPHRAGM IN CIRCULAR CELL.

Although the diaphragm disintegrates, this seems to do no harm, provided the pieces can be kept in place. To this end the scheme may be adopted of making a diaphragm of asbestos by packing it between two perforated tubes, as shown by Fig. 15, in which "A" is the plan view, and "B" is a sectional elevation of the cell.

The carbon anode, a, is placed inside of the diaphragm, which is built up of two perforated walls or holders, b and d. The intermediate space, c, is filled with asbestos or other porous substance. The outer holder, d, may be made of iron; indeed a piece of wire screen will answer perfectly for this. The inner holder, b, must be made of some substance not attacked by chlorine; wire screening may be used for this holder also, but it must be so protected by tar, asphaltum or some similar substance that it cannot be attacked by the acids or gases. The space between the two may be tightly packed with fibrous asbestos, like that used for packing asbestos valves, etc.

Another form of construction is shown by Fig. 16. This cell, although belonging to the double fluid and diaphragm class, really contains only a single fluid, the anode, a, being composed of broken carbon or gas coke placed inside of the diaphragm, b, which virtually serves as a containing vessel or holder for the carbon anode. Such a construction is easily effected; a wooden or metal form of the required diameter is wrapped to the necessary thickness with asbestos paper; then a woven wire jacket is snugly fitted to the outside of the asbestos and the diaphragm is complete.

The anode is a piece of carbon with a hole drilled in it into which a heavy insulated copper wire is secured, the lower end of the wire having been bared and cleaned before putting it into the hole. Melted lead is poured into the hole around the wire, fixing it in place. A coating of tar or other protecting substance is then applied to the junction of the wire and carbon, and the latter is placed in a cavity formed by removing the wooden core from the asbestos diaphragm. Quite large pieces of coke or carbon are packed into the diaphragm, care being taken to have the mass very porous in order to admit of the free passage of the chlorine gas which is evolved at the points of contact between the anode and the diaphragm. A dome, e, is fastened air-tight over the anode and diaphragm to collect the chlorine, which is led away to the lime vats by the pipe, f.

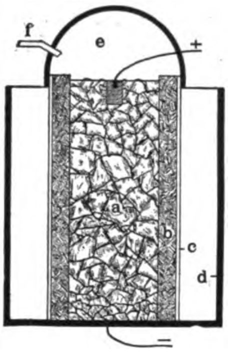


FIG 16.—COMBINED ANODE AND DIAPHRAGM

According to theory, this form of construction for an electrolytic cell possesses many advantages. The anode may disintegrate, yet it cannot get out of shape; the diaphragm may swell and come apart, but it cannot get away because it is held by the anode on one side and a stout sheet of woven wire on the other; the electrical resistance must be low, because the section of liquid is very thin and virtually is in immediate contact with the anode; there can be no contamination of the ions, because no soda can get into the anode, the pressure of the electric current effectually preventing that; the process can be easily made continuous, because the salt solution can flow into the top of the cell, d, and the caustic soda solution can be drawn off from the bottom of the cell as fast as it is deposited.

With this cell, as with all others, there are weak points. All of the chlorine must pass through the diaphragm; the soda is deposited on the outer surface of the diaphragm and the surface of cathode; the chlorine must go to the anode, and to do it must pass through the pores of the diaphragm. This is accomplished all right as long as the pores are large enough and the current is flowing. As soon as the current stops and the apparatus is allowed to stand, the salt solution will tend to penetrate the diaphragm and the chlorine will work out through it and attack the woven wire covering. Again, after considerable use the pores of the diaphragm will become clogged or stopped up, rendering it impervious to passage of the chlorine. When this occurs, and enough voltage is applied still to force current through the apparatus, the diaphragm will become as a part of the anode, and chlorine will be liberated outside of the wire cloth in the main cell, d. Such an occurrence practically transforms the apparatus into a single fluid cell, with all of the disadvantages belonging to that cell. Another thing which will eventually cause trouble in this kind of a cell, even if the diaphragm is kept porous by renewal, is the clogging of the cavities in the anode, making necessary frequent overhauling and cleaning of that electrode also a necessity.

A RUNNING TEST ON STREET CAR MOTORS.

BY E. C. PARHAM.

Voltage applied to any circuit distributes itself according to the resistance it meets; if there are several resistances in series in a circuit the greatest drop in voltage will be found to take place across the greatest resistance. This is sometimes disadvantageous. If a circuit gets open at any point the resistance of the opening is so great, compared to that of all the rest of the circuit, that almost all of the drop takes place across the break and supports an arc that may do a great deal of damage. The wheels under an electric car sometimes slip so badly that the car cannot be started properly; this is because as soon as one pair of wheels starts to slip, the motor that is geared to them takes all the line voltage to itself, and does not leave enough to drive the other motor. Here the distribution of voltage according to the opposition of different parts of the circuit is a disadvantage. On the other hand this property forms the basis of a very useful test for finding out if the two motors on a

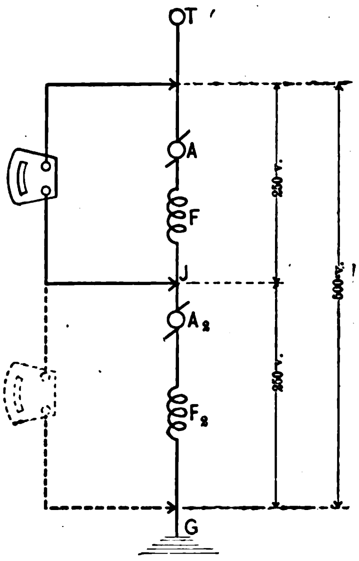


FIG. 1.—TEST CONNECTIONS.

car are balanced. If the motors are not nearly balanced, one will take more load than the other, and in course of time this fact will assert itself by causing the motor to heat, spark, throw solder and roast its field coils.

On all modern cars the series-parallel controller is used, which starts the motors in series, and, after they are up to half speed, throws them into multiple. Now each motor armature develops a back pressure, called counter e.m.f., which limits the value of the current after all of the starting resistance has been cut out. When the motors are in series these counter e.m.fs. are in series too, and if motors are alike in every respect their counter e.m.fs. will be the same. This can be tested by connecting a voltmeter across the terminals of the two motors, one at a time, as indicated in Fig. 1, where T is the trolley wire and G is the rail or ground; A and F are the armature and field of the No. 1 motor, A2 and F2 the armature and field of the No. 2 motor. The full lines show the voltmeter connected to indicate the drop across the No. 1 motor, and the dotted lines indicate the connections for taking the drop on the No. 2 motor.

When one wire of the voltmeter is held on T and the other on G it indicates the full voltage of the line; when applied to either motor alone, the meter will indicate one-half the line e.m.f. if the two motors are alike. In transferring the connections from one motor to the other both test wires must be transferred and their positions relative to the trolley and the ground must be kept the same, or the needle will throw the wrong way, unless the instrument is an alternating-current voltmeter. That is to say, it will not do to permanently connect one wire to the point, J, midway between the motors, and shift the other wire over from the trolley to the ground. As a rule, the two readings will not be the same, because in the first place no two motors are ever exactly alike, and even if they did happen to be alike there are several conditions of variation which affect the counter e.m.f. of the motors and therefore affect the line drop across their terminals. Under average normal conditions the drops across the two motors will differ as much as 10 or 15 volts. Among the causes that help to make the two drops differ are the following:

(1). The steel of which the two motors are cast may not be exactly of the same quality, so that even with the same current in the field coils one motor may have more lines of force in its armature than the other.

(2). The horns of the pole-pieces on the two motors may be rounded off to a different degree, or their polar faces may be bored out to slightly different diameters (no two machinists can caliper alike) or the armature teeth when cleaned up with a file may have been dressed to slightly different curvatures. Any of these three differences affects the reluctance that the air-gap offers to the lines of force and therefore affects the number of lines of force that are cut by the armature wires when the armature rotates.

(3). The armature bearings may be worn down on one motor and new on the other. The effect of wear in the bearings is to let the armature down out of a central position, where it is the same distance from all of the pole-pieces, to a position where the upper pole-pieces may be half an inch from the core and the bottom ones almost rubbing it. The result of this is to make some of the lines of force due to the field go where they can be of no use, but actually do harm by causing the motor to spark.

(4). The brushes may not be the right distance apart, due to shrinkage of the wooden brush yoke or to a fault in the yoke or some casting; or they may be the right distance apart but not on the proper commutation points of the commutator. The brushes are supposed to set at equal distances on both sides of the commutator's vertical radius; if they set at equal distances on opposite sides of some other radius the counter e.m.f. is affected. The truth of this has been demonstrated by the fact that when the car is running in one direction and the drops are taken on the two motors, the drops may be the same; while if the car is run in the opposite direction one drop will be greater than the other.

(5). The relative drops across the motors are also affected if the commutators are of different sizes; the motor with the larger commutator will have the higher drop.

(6). One motor may be geared to a pair of new wheels, the other motor to a pair of old ones. The old wheels are worn to a smaller diameter than the new ones are, and this allows the armature that is geared to them to revolve faster than the one that is geared to the new wheels. The armature geared to the old wheels will therefore have the higher counter e.m.f., and the greater drop will take place across it.

(7). There may be a difference in the ohmic resistance of the two motors, due either to the fact that there may be a slight difference in the size or amount of wire used on them, or to the fact that one motor is hotter than the other.

Any of these faults will cause a slight difference in the relative drops across the two motors, but to avoid them all is impracticable. The most serious cause of want of balance in two motors is a fault in the field magnet or coils; the field coils may be connected wrong or they may be roasted, or the pole-pieces may be loose, or the motor shell may not be tightly closed. Any of these faults will cause the effect well known among car-house men as due to "weak fields," and their final effect, if allowed to continue, is to make the car buck and blow fuses. If a car motor has "weak fields," whatever it may be due to, one motor takes more load than the other, and in some cases the faulty motor will take more load than both of them ought to take. The cause of such an overload is that as the fields are weak they provide very few lines of force for the armature wires to cut, and consequently the counter e.m.f. of the armature is low, so that more current is forced through the motor by the line e.m.f. When the motors are in series the two counter e.m.fs. help each other to keep down the current flow, so the current does not get large enough to do any damage.

As one motor armature has a higher counter e.m.f. than the other, the voltmeter will indicate a higher drop between the terminals of one motor than between the terminals of the other. In this case the motor with the good fields has the higher counter e.m.f. and the one with the weak fields has the lower. Therefore in taking the drops across two motors in series when one has weak fields, this one will show a lower drop across its terminals. It is customary in making the tests on a car to measure the drop on the armatures alone. The one that gives the lower drop runs in the weak fields. The armature terminals can be gotten at in the controller. In making the test it is best to have the car run on the series notch that has all of the starting coil cut out; this is generally the fourth or fifth notch on modern controllers. The test had best be made on a long stretch of level track or on a long grade, where the load will be constant and the current steady long enough for two readings to be taken, one from one motor and one from the other, without danger of having different conditions for the two readings. It is a good plan to test the e.m.f. at the armature terminals under the various running positions of the controller which put the motors in series. If the tests show the motors to be balanced on all notches except the shunt or loop notch, it shows that something is wrong with one of those devices.

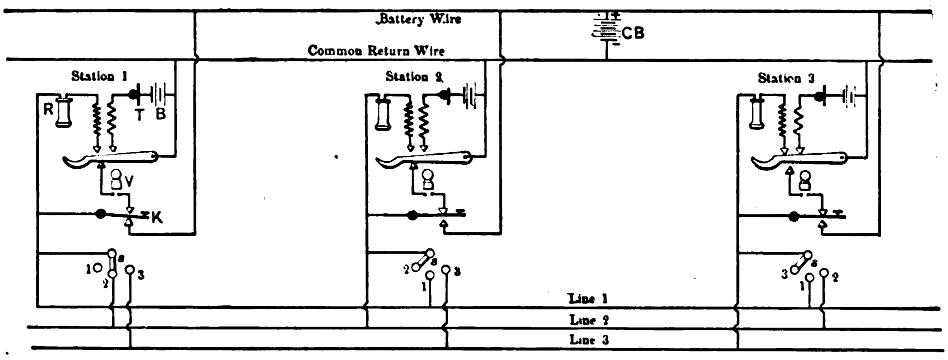


FIG. 20.—COMMON SIGNALLING-BATTERY SYSTEM.

INTERIOR TELEPHONE SYSTEMS.

BY W. S HENRY.

INTERCOMMUNICATING SYSTEMS.

As pointed out in the preceding article, a good deal of trouble is experienced with intercommunicating systems like or similar to that of Fig. 20 by reason of the user carelessly leaving the selective switch, S, off the home button after using the telephone. Fig. 21 shows a method of wiring such a system which obviates to a considerable extent this trouble. Here, the vibrating bell is permanently connected to the home button and the pivot of the switch, S, is connected to the arm of the push switch, K. Any station can still be called up no matter on what button its switch, S, may be left.

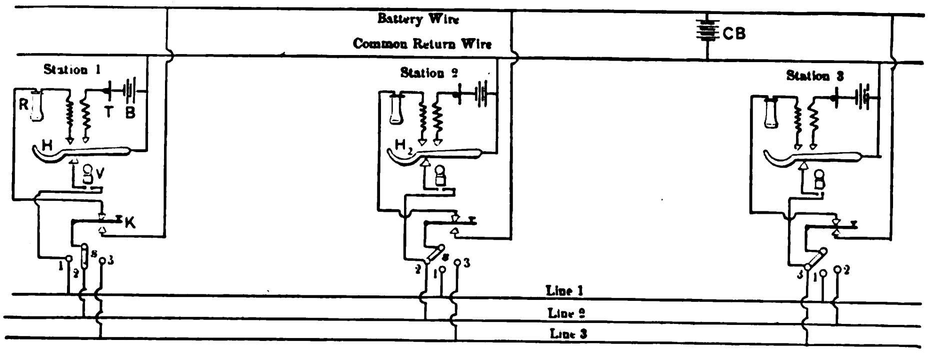


FIG. 21.—COMMON SIGNALLING-BATTERY SYSTEM.

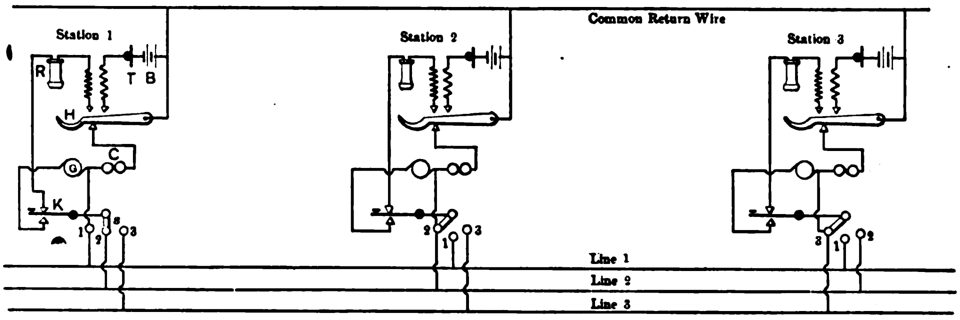


FIG. 22.

However, if Station No. 1, for instance, should call up Station No. 2 and the switch at Station No. 2 was not on the home button, the bell at No. 2 would ring, but when the receivers were removed it would be impossible to hold a conversation because line 2 is open at Station No. 2 at the contact on the underside of the hook switch, H2. No. 2 not being able to hear anything will naturally, if proper instructions are tacked up on the telephone, look at the intercommunicating switch and finding it off the home button, will return it to that button, after which the conversation may be held. This compels the return of the switch to the home button at the station called before the conversation can be held, and tends to cultivate the habit of returning the switch to the home button after each conversation.

This system has been found to work more successfully than the preceding one. Furthermore, the talking current flows only through the two stations properly connected; it does not sub-divide through any other station, no matter where the switches at the other stations may be left. Suppose Stations No. 1 and No. 2 are properly connected by having the switch S at Station No. 1 on button 2 as shown and holding a conversation and that the switch at Station No. 3 is on button 1 or 2. The receivers at Stations No. 1 and No. 2 are off the hooks so that their bells and home buttons are on open circuit at the under contacts of the hook switches.

Line 1 will evidently be open at the under contact of the hook switch at Station No. 1 and line 2 open at Station No. 3 at the upper contact on the switch hook, even if the switch at Station No. 3 is on button 2. Hence none of the talking current between Stations No. 1 and No. 2 can pass through Station No. 3, even if the switch at Station No. 3 is left on buttons 1 or 2, unless with the switch in the latter position the receiver at Station No. 3 had also been left off the hook. Such carelessness as leaving a receiver off the hook when through with the telephone is inexcusable, although leaving the switch off the home button may be. The former does not occur very often.

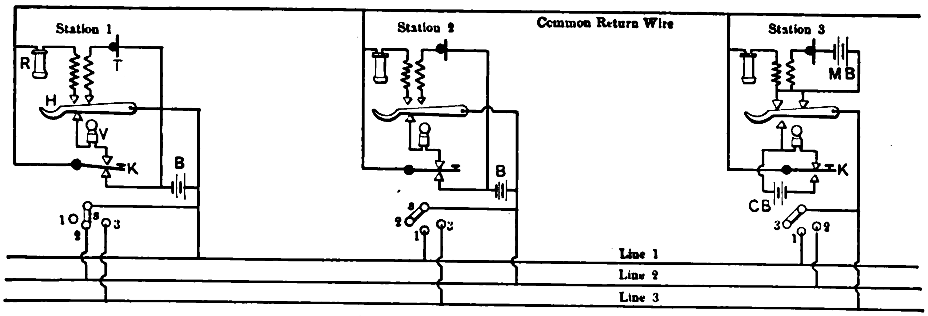


FIG. 23.—COMBINATION SYSTEM

This arrangement of the connections does not prevent the sub-dividing of the ringing current, but it tends to reduce the number of switches left on other than the home buttons. This is probably the best arrangement of switches and connections for an intercommunicating system using a common calling battery with induction coils and a transmitter battery at each station, where no automatic restoring device is employed.

The same system of wiring employed in Fig. 21 is applied to the system shown in Fig. 22, in which magneto-generators, G, and polarized bells, C, are used in place of the battery and vibrating bells. There is no need of having a push button or automatic shunt on the generator, although it will do no harm whatever if there is one. The generator is normally on open circuit because one of its terminals is connected to the under contact of the push switch, K. In order to call up a station, the switch, S, is placed on the button belonging to the station desired, the push switch, K, depressed, and the generator handle turned. Since no common battery is employed for ringing, this system requires one less wire through all the stations than the preceding arrangement. In all other respects the system is similar to the one just described and shown in Fig. 21.

In Fig. 23 is shown an intercommunicating system employing a transmitter, receiver, induction coil, vibrating bell, push switch, K, and a strap switch, S, at each station. At Stations No. 1 and No. 2 there is one battery, B, used both for ringing and talking, and at Station No. 3 two batteries, one, CB, for ringing and another, MB, for talking. The batteries must be strong enough for the two most distant stations to call up one another and converse. Where a battery of the same number of cells is not suitable both for ringing and talking, two separate batteries, as arranged at Station No. 3, would be necessary. This system requires only one more wire throughout than there are stations. As the bells are connected, and they cannot well be arranged otherwise, only the bell at the station called will ring. The vibrators must not be short-circuited or altered on any of the bells. The connections at the selective switch and the operation of the system are the same as in Fig. 20.

JET AND SYPHON CONDENSERS.

BY JAMES F. HOBART.

One of the earliest forms of condenser if, in fact, not earliest form of all, is the jet condenser, usually arranged as shown by Fig. 1. This condenser acts by a direct mingling of the cooling water with the exhaust steam. As the steam comes in immediate contact with the water it is condensed without the necessity of transmitting the heat through metal tubes before it can be abstracted from the steam, as is the case when the surface condenser is used. On a jet condenser all the water put into the device, together with the water of condensation and any air that may be in the steam, must be pumped out of the apparatus after the steam has been condensed. Therefore, there is a considerable power consumption in the operation of this type of condenser, but when the pumps are operated by direct connection, or by belt, or even by electricity, there is not a heavy percentage of waste.

As shown by the illustration the exhaust steam passes from the engine to the condenser where it meets a jet or spray of water, the supply of which should flow by gravity to the condensing chamber if possible, but which may be lifted a short distance by the condenser action if necessary. In this case, there must be means for priming the condenser before it can start. A priming pipe for this purpose is shown in the engraving, the priming valve being marked E.

The so-called air-pump is the most important part of this apparatus, and without an efficient device for removing the water the condenser will be worse than useless, for it will fill with water which may back up into the engine and wreck the cylinder. To obviate this, some form of vacuum-breaker should always be provided. Many of the jet condenser manufacturers fit their condensers with automatic vacuum breakers which open and admit the atmospheric pressure when the water level rises too high in the condensing chamber. In several condensers the device takes the form of a float and valve so arranged that when the water rises the float is carried up, and when the water level gets too high the float actuates a valve opening into the atmosphere, breaking the vacuum.

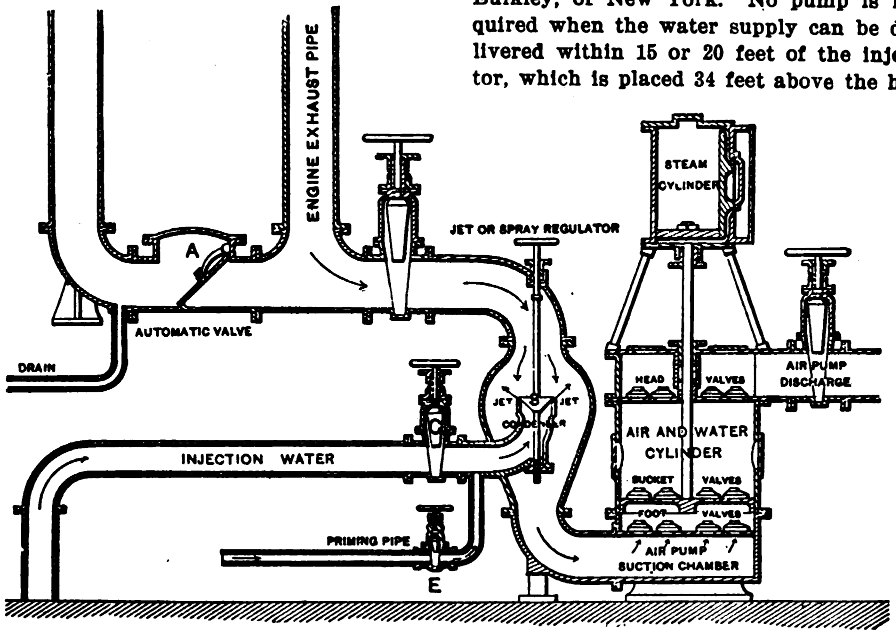


FIG. 1.—USUAL ARRANGEMENT OF A JET CONDENSER AND AIR-PUMP.

Another form of condenser very similar to the ordinary jet arrangement is the syphon condenser, shown by Figs. 2 and 3. Here the cooling water and exhaust steam mix, just as in the jet condenser, but the vacuum, instead of being maintained by an air-pump, is caused by the fall of a column of water. Fig. 2 represents the Bulkley injector condenser, made by H. M. Bulkley, of New York. No pump is required when the water supply can be delivered within 15 or 20 feet of the injector, which is placed 34 feet above the hot well. The condensing water enters at the side, and passes downward around the exhaust nozzle. The exhaust steam is thus condensed within a hollow cone of falling water, which by its velocity through the contracted neck of the condenser, expels the air and vapor, into the discharge pipe below. The nozzle is 34 feet above the hot well, making the column in the discharge pipe long enough to overcome the pressure of the atmosphere; the water being delivered into the hot well by gravity. A high vacuum is thus maintained, and may be formed before the engine is started.

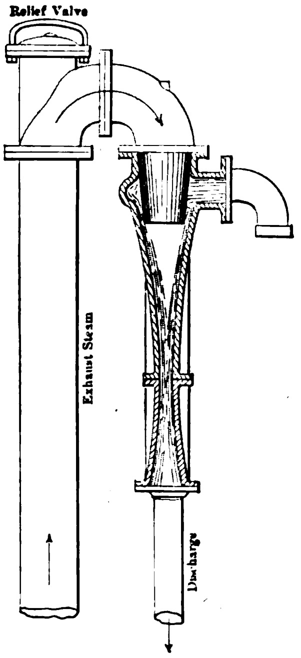


FIG. 3.—BULKLEY SYPHON CONDENSER.

The Knowles spirajector condenser, made by the Knowles Pump Company, is similar to the Bulkley, except that vanes cast upon the face of the cone force the injector water to assume a spiral or rotary motion as it passes through the condenser.

The Baragwanath condenser, made by William Baragwanath & Son, Chicago, and shown herewith by Fig. 3, is much like the one shown by Fig. 2. Indeed, the arrangement is identical with the exception of the adjustable cone shown in Fig. 3. This appliance is also called a water-jacket condenser; the water chamber is larger than in the other apparatus, and the shell of the condenser is prolonged inside the water chamber, forming an inverted cone into the end of which the condensing nozzle projects. This nozzle is adjustable by the spindle shown, so that the cone can be set to admit exactly the right quantity of water necessary to condense the steam to be handled. Each of the three syphon condensers here described has an automatic relief valve which prevents trouble when the injector "breaks" by allowing the exhaust to pass directly into the atmosphere.

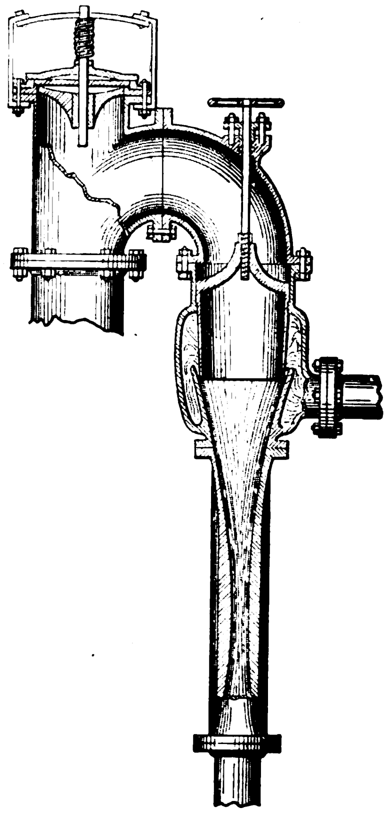


FIG. 3.—BARAGWANATH SYPHON CONDENSER.

Another type, the exhaust-steam induction condenser, is little known and seldom used. This device works upon the same principle employed in ordinary injectors and means are employed for regulating so as to take care of a varying amount of exhaust steam. This type of condenser was originally designed by the Kortings, but is little used in this country.

Lessons in Practical Electricity

CORE AND COPPER LOSSES IN TRANSFORMERS.

In the preceding lesson only that part of the core-loss due to hysteresis was considered. There is in addition to this the loss due to eddy currents—currents induced in the plates of the core. It will be evident upon consideration that if the alternating magnetic flux induces an e.m.f. in wires wound around the core it will induce an e.m.f. in any conducting material disposed at right angles with the magnetic path. The surfaces of the core plates may be considered as very wide and very thin conductors wrapped around the interior, just as though one took a strip of metal, say 1/10,000 inch thick, of a width equal to the length of a core plate and wrapped a single turn about each individual plate of the transformer core, welding the ends together so as to provide a closed circuit. An e.m.f. would be induced in such a conductor just as in the wires of the coils, and as its resistance would be comparatively low the current flow would be enormous but for the fact that the inductive effect on the side of one core plate is largely opposed by that on the side of the core plate next to it. (See Fig. 20.)

Hence, the flow of the eddy currents around the surfaces of the individual core plates is not regular, and cannot be computed by the formula which would apply to a thin insulated sheath wrapped about a single core plate magnetized separately from its fellows. From a formula deduced by Mr. Steinmetz is obtained the following expression for watts absorbed by eddy currents per cubic inch of iron in the core:

$$\frac{4\ 18 \times t^2 \times n^2 \times B^2}{100,000,000,000} = P_e \ldots\ldots (8)$$

in which "t" is the thickness of the core plates in inch measure; "n" is the frequency, and "B" is the magnetic density in lines per square inch of core cross-section.

The above formula is easier of application than the one for hysteresis loss previously given, but for the convenience of the learner and to avoid arithmetical digression Table II has been computed; this gives the core-loss by eddy currents per cubic inch of iron and per cycle per second, the loss being so small that it is expressed in microwatts (a microwatt is one-millionth of a watt). In Table III are given both the hysteresis and eddy current losses, singly and combined, for the two common frequencies and two thicknesses of transformer iron; the losses here are expressed in watts.

TABLE II.

LOSS BY EDDY CURRENTS IN MICROWATTS PER CUBIC INCH OF CORE AT ONE CYCLE PER SECOND.

B	t=0.01	t=0.012	t=0.015	t=0.018	t=0.02
18,000	1.314	1.95	3.047	4.388	5.257
20,000	1.672	2.408	3.762	5.417	6.688
22,000	2.023	2.913	4.552	6.555	8.092
24,000	2.408	3.467	5.417	7.8	9.631
26,000	2.826	4.069	6.358	9.155	11.303
28,000	3.277	4.719	7.373	10.618	13.108
30,000	3 762	5.417	8.464	12.189	15.048
32,000	4.28	6.164	9.631	13.868	17.12
34,000	4.832	6.958	10.872	15.656	19.328
36,000	5.257	7.8	12.189	17.552	21.028
38,000	6.036	8.692	13.58	19.556	24.144
40,000	6.628	9.631	15.048	21.669	26.752
42,000	7.373	10.618	16.59	23.89	29.394
44,000	8.092	11.653	18.208	26.219	32.368
46,000	8.845	12.737	19.9	28.657	35.38
48.000	9.631	13.868	21.669	31.203	38.524
50,000	10.45	15.048	23.512	33.857	41.8
52,000	11.303	16.276	25.431	36.62	45.212
56 000	13.108	18.876	29.494	42.471	52.432
60,000	15.048	21.669	33.858	48.755	60.192
64,000	17.12	24.655	38.523	55.472	68.48

To ascertain the eddy current loss in watts for any core and frequency, multiply the proper number in the table by the cubic inches of iron in the core and by the square of the frequency; divide the result by 1,000,000.

TABLE III.

CORE LOSSES IN WATTS PER CUBIC INCH OF CORE.

Magnetic Density	n = 60 cycles.					n = 133 cycles				
	Hysteresis	0.012-in. iron.		0.015-in. iron.		Hysteresis	0.012-in. iron.		0.015-in. iron.	
B.	Ph	Eddy Pe.	Total.	Eddy Pe.	Total.	Ph.	Eddy Pe.	Total.	Eddy Pe.	Total.
18,000	.106	.007	.113	.011	.117	.236	.0345	.2705	.0539	.29
20,000	.126	.0087	.1347	.0135	.1395	.279	.0426	.3216	.0665	.3455
22,000	.145	.0105	.1555	.0164	.1614	.325	.0516	.3766	.0805	.4055
24.000	.168	.0125	.1805	.0195	.1875	.374	.0614	.4354	.0958	.47
26,000	.192	.0146	.2066	.023	.215	.425	.0721	.497	.1125	.5375
28,000	.215	.017	.232	.0265	.2415	.478	.0836	.5616	.13	.608
30,000	.24	.0195	.2595	.03	.27	.534	.096	.63	.15	.684
32,000	.267	.0222	.2892	.0316	.3016	.592	.109	.701	.17	.762
34,000	.294	.025	.319	.039	.333	.653	.123	.796	.192	.845
36,000	.322	.028	.35	.044	.366	.715	.138	.853	.216	.931
38,000	.351	.0313	.3823	.049	.4	.78	.154	.934	.24	1.02
40,000	.381	.0347	.4157	.054	.435	.846	.17	1.016	.266	1.112
42,000	.412	.038	.45	.06	.472	.915	.188	1.103	.293	1.208
44,000	.444	.042	.486	.0656	.5096	.986	.206	1.192	.322	1.308
46,000	.476	.046	.522	.072	.548	1.058	.226	1.284	.352	1.41
48,000	.51	.05	.56	.078	.588	1.133	.246	1.379	.383	1.516
50.000	.544	.051	.598	.085	.629	1.21	.267	1.477	.416	1.626
52,000	.583	.058	.641	.092	.675	1.288	.288	1.576	.45	1.738

FIG. 20

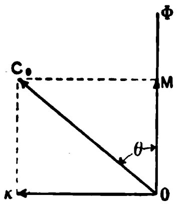


FIG. 21.

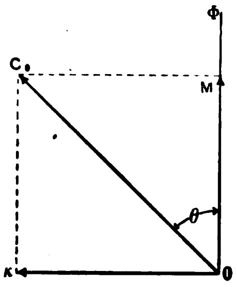


FIG. 22.

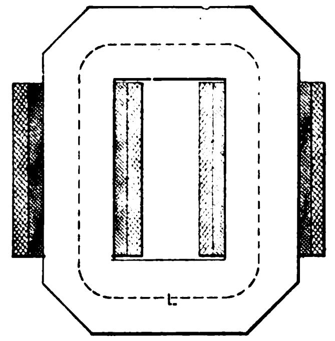


FIG. 23.

As previously stated, the losses by hysteresis and eddy currents cause the phase of the magnetic flux to lag behind that of the exciting current, as indicated in Figs. 21 and 22, where the magnetic phase is represented by the line 0Φ and that of the exciting current by $0C_0$. The cause of this is that the exciting current consists of two components, one the purely magnetizing force, M, in phase with the flux, and one the core-loss current κ, in quadrature with the flux. It will be clear, therefore, that the extent of the angle, θ, between the exciting current phase and the flux phase depends upon the ratio of the core-loss current to the magnetizing current. The tangent of the core-loss angle, by elementary trigonometry, is obviously

$$\tan\theta = \frac{\kappa}{M} \ldots\ldots\ldots (9)^*$$

It is seldom of any importance to others than transformer builders to ascertain the value of the core-loss angle; it is merely a measure of the relation between the core-loss and magnetizing components of the exciting current, and can be ascertained by plotting the two to scale and measuring the angle on the diagram.

As explained in the July lesson, when a transformer is changed from a higher to a lower frequency the magnetic flux increases automatically to make up for the decrease in alternations. This will be best understood by working out a concrete example. Assume a core-type transformer, like Fig. 23, designed for a 1000-volt primary circuit. Say that its dimensions and characteristics are as follows:

	At 133 cycles.
Core section, A	8½ sq. in.
Length of path, L	28 in.
Thickness of iron, t	0.015 in.
Magnetic density, B	20,000
Total flux, Φ	170,000
Permeability, μ	1770
Primary turns, N_p	1000
Primary resistance	2 ohms.
Primary full load current	5 amps.

The magnetizing current, M, is

$$\frac{.2215 \times B \times L}{\mu \times N_p} =$$

$$\frac{.2215 \times 20,000 \times 28}{1770 \times 1000} = 0.07 \text{ ampere.}$$

---

* This formula, expanded, results in the following:

$$\tan\theta = \mu\left(\frac{0.00618\ B^{-.4} + 0.00094\ n\ t^2}{0.2215}\right)$$

From Table III the core-losses are 0.3455 watt per cubic inch, and there are practically 240 cubic inches, so that the core-losses are 83 watts. The e.m.f. being 1000 volts, the core-loss current, κ, is 0.083 ampere, and the exciting current, C_0, is

$$\sqrt{M^2 + \kappa^2} = 0.1086 \text{ ampere.}$$

The resistance of the primary being 2 ohms, the no-load copper loss will be

$$C_0^2 \times R =$$
$$.011794 \times 2 = .023588 \text{ watt,}$$

which is an insignificant addition to the core losses of 83 watts.

Now put this transformer on a 60-cycle circuit. The counter or induced e.m.f. must still be practically 1000, and according to formula (2), July lesson,

$$\frac{4.45 \times n \times \Phi \times N^p}{100{,}000{,}000} = E,$$

therefore,

$$\frac{100{,}000{,}000 \times E}{4.45 \times n \times N_p} = \Phi \ldots\ldots. (10)$$

This makes the flux 377,000,000 lines, and dividing by the core area of 8½ sq. ins. gives the density, which is 44,444. This could have been arrived at more directly by taking 133/60 of the first density, in accordance with the rule that

The density varies inversely as the frequency, in a constant-potential transformer.

With this density the permeability of the iron rises to about 2300, so that the magnetizing current, M, is

$$\frac{.2215 \times 44{,}444 \times 28}{2300 \times 1000} = \text{practically } 0.12.$$

According to Table III the core losses are about 0.51 watt per cubic inch, or 122.4 total. A tabulated comparison is given below:

	133 cycles.	60 cycles.
Density	44,444	20,000
Core losses, watts	83	122½
Core-loss current	0.083	0.1224
Magnetizing current	0.07	0.12
Exciting current	0.1086	0.1714
Exciting power, watts	83.0236	122.46
Copper loss in primary at full load, watts	50	50

The increased core losses at 60 cycles, due to the increased density, also affect the core-loss angle. Fig. 21 shows the angle at 133 cycles and Fig. 22 the angle at 60 cycles; in the first case it is very nearly 50°, and in the other it is a trifle over 45½°. The case assumed above is a little exaggerated. Generally, the magnetizing component is considerably greater than the core-loss component of the exciting current.

The copper loss in the primary is the same at both frequencies, being simply the primary resistance multiplied by the square of the full load primary current. The secondary copper loss is usually about the same as that in the primary, so that the full load losses, total, for the above transformer, may be summed up thus:

	133 cycles.	60 cycles.
Total core loss	83	122½
Total copper loss	100	100
	183	222½

The conclusions to be drawn are that transformer losses increase slowly as the frequency decreases; the increase in losses is entirely in the core; and the rate of increase in core losses depends upon the quality and thickness of the core plates.

Letters on Practical Subjects

Grounding Interior Conduits.

To the Editor, American Electrician;

Sir:—Referring to Mr. Alfred W. Watkins' letter in the June number, about interior conduits, I would say that he is quite justified in asking how conduit can be permanently and effectually grounded when common japanned pipe is used with the threads and couplings pretty well insulated on account of careless work and no surface to ground. The Board of Underwriters has asked for galvanized pipe with a smooth interior, but this is very hard to get on account of the galvanizing running very poorly on the interior of pipe. There is a galvanized conduit, however, which would seem to fill all of the requirements, from what I can understand; this conduit is first reamed to get a smooth interior and uniform bore, and it is electro-galvanized to obtain a uniform coating all over, even to threads. The interior only is covered with a flexible enamel, and no fish lines are required to get conductors through this conduit or race-way. If Mr. Watkins wants to use the Edison 3-wire system he can use this conduit for the neutral wire, provided that instead of using a cap on the grounding end, the pipe should be grounded itself for at least five feet.

By running or driving 5 or 10 ft. of conduit pipe into the ground, a good ground is at once insured, for this would drain the entire system of moisture (which does not help the insulated conductors any). This drainage would keep the grounded end always moist and that would give a permanent ground in every sense of the word and a longer life to the insulation of the conductors or insulated wire, for one of the main objects is to keep the wires as dry as possible.

Chicago, Ill. E. M. Jones.

◆

Neutral, Not Negative.

To the Editor, American Electrician;

Sir:—On your Queries and Answers page of the August issue, your answer to A. P. L.'s second question, "What would happen if the fuse of the negative wire should blow at the station?" evidently assumed that the neutral wire is the one meant, as your reply: "Nothing, as long as the loads are equal on each side of the neutral. If the loads are unbalanced, then the lights on the lightly loaded side would be likely to burn out, or else those on the heavily loaded side would grow very dim," states what would occur if a fuse in the neutral wire should blow. If the increased line loss is disregarded, the only effect the blowing of a fuse in the negative wire would have would be to extinguish all lights on that side of the system. In practice, however, it is customary to make the neutral about half the size of the outside wires; in this case, should the negative or positive fuse blow, the drop on the other side of the system would be about three times what it was with both sides burning and the loads evenly divided on each side of the neutral, and would be very noticeable at the lamps.

L. D. Gray.

Rock Springs, Wyo.

[The original query specified the neutral wire; the word "negative" was a typographical error, noted too late for rectification.—Editor.]

◆

A Condenser that Didn't Condense.

To the Editor, American Electrician;

Sir:—I was recently called on to test some condensers that were not condensers at all, having no capacity, and, indeed, testing as if they had no dielectric. Upon questioning the owner I found that they were made in a machine shop where there was brass and copper dust flying around; that the parrafine was boiling hot, and that he did not remember whether there were any air bubbles on the sheets or not; nor did he seem to care. There was, however, one feature about them that he seemed to think beyond criticism, and that was: "The paper I used was the best German drawing paper, good and thick, so there would be no chance of a hole in it to spoil my condensers!"

Once in a while you will run across this kind of a man, and, worse luck, he generally has "Electrician" printed on his business card.

Sidney Aylmer Small.

Columbia University, New York.

◆

The Removal of Oil from Exhaust Steam.

To the Editor, American Electrician;

Sir:—Referring to Prof. Carpenter's article on Condensers, which appeared in your August issue, it would be of interest if Prof. Carpenter would explain in more detail how to remove oil from exhaust steam going to a surface condenser and also an efficient method of removing oil from the water of condensation. It would also be of interest if he would give methods for preventing injury to boilers, especially of the water-tube type, due to oil entering with the feed water when the condensed exhaust is used.

H. R. Burton.

Port Richmond, N. Y.

◆

Testing Damaged Armatures.

To the Editor, American Electrician;

Sir:—Referring to the method proposed by Mr. Hugo Altmayer in your August issue for locating a burnt-out armature coil, I would say that I have never found any instrument necessary for this purpose. An open coil in a direct-current armature will show itself on the commutator by burning a hole in the edge of the segment between the open coil and the one just ahead of it in the direction of rotation. Mr. Altmayer's method for finding a short-circuit is a good one, but is not new.

Frank Hoffman.

Chicago, Ill.

Mechanical Stokers.

To the Editor, American Electrician:

Sir:—I have read with much interest the article in the August issue by Mr. A. L. Harrison relating to a previous article by Mr. James F. Hobart on Mechanical Stoking, and I would suggest that Mr. Harrison be induced to go farther and give the whys and wherefors of economy and general utility of stokers; the points to be guarded in making the "judicious choice" several times referred to, as well as other practical information which he appears to possess. It would be interesting, for instance, to have his experience as to the rate of combustion or pounds of coal per square foot of grate it is practicable to burn, and also what coals are best adapted for use with stokers.

C. B. Miller.

Chicago, Ill.

Electrical Catechism

513. What is a mile-ohm?

The mile-ohm is a term used in connection with telegraph and telephone wire. It is the resistance of a wire one mile long and weighing one pound. The mile-ohm of pure iron is about 4,000, the specifications of the Western Union Company calling for not more than 4,800, the British Post-Office calling for not more than 5,323. The "mile-ohm" is really an abbreviation for "weight per mile-ohm," and is sometimes called "pound-mile-ohm." The former specifies "the electrical resistance of the wire in ohms per mile, at a temperature of 68 degrees Fahrenheit, must not exceed the quotient arising from the dividing the constant number 4,800 by the weight of the wire in pounds per mile. The coefficient .003 will be allowed for each degree Fahrenheit in reducing to standard temperature." One mile-ohm of copper at 60 degrees Fahrenheit equals 859 international ohms, or 861 legal ohms, or 868.9 B. A. units.

514. What is a megohm?

A megohm is one million ohms. It is a unit often used in measuring very high resistances, such as insulation. For instance, when a wire is guaranteed to have an insulation resistance of not less than 300 megohms per mile, it means that the resistance between the wire and the earth or the lead covering is not less than 300,000,000 ohms for a length of one mile and proportionally greater for shorter lengths.

515. What wire gauges are in common use?

That in most common use in America is the Brown & Sharpe gauge, often abbreviated to "B. & S. G.," and frequently called American gauge. Iron wire is generally made according to the Birmingham wire gauge, often abbreviated to "B. W. G." Other gauges sometimes used are the Washburn & Moen, the Roebling and the New British or Standard gauge. Wires are often designated by their diameters without reference to any gauge. Very large cables or bars are usually designated by the number of circular mils in their area.

516. Are there any easy rules for remembering the wire table?

The Brown & Sharpe gauge can be remembered easily, at least the sizes of wire most commonly used. No. 10 wire has a diameter of about 0.10 inch, and has a resistance of one ohm per thousand feet, runs 31 feet per pound when bare and has a safe carrying capacity of 23 or 32 amperes, according to circumstances. The diameter of other sizes increases about 0.01 inch as the number decreases; the area doubles every third number, and the safe carrying capacity doubles every fourth number. Thus, No. 10 has twice the area of No. 13 and half the area of No. 7; it has twice the carrying capacity (for given rise in temperature) of No. 14 and half the capacity of No. 6. The wire table in the appendix may be examined profitably to see how closely these rules hold true.

517. Is a circuit likely to have more than one electro-motive force?

The principal E. M. F. causing current to flow in the circuit may be in one or more sections which may be in one or more parts of the circuit. Besides these there may be opposing E. M. F.'s, or counter E. M. F.'s, which may or may not vary with the amount of current in the circuit. The fall of potential as the current overcomes resistance is sometimes called an E. M. F., as it is measured in volts, although it is more common to call it "ohmic drop" or simply "drop."

518. What are the distinctions between E. M. F., C. E. M. F., fall of potential, drop, difference of potential and ohmic drop?

E. M. F. generally refers to the preliminary cause of the current, or the "electricity moving force." Ohmic drop, or simply drop, refers to the fall of potential caused by the resistance met by the current, and equals the product of current by resistance; the drop may refer to the resistance of the entire circuit or to that in any specified part of it. Counter electro-motive force is usually a result of the passage of the current causing some inductive, chemical or equivalent action, which would of itself tend to send a current in the opposite direction, a simple case being a storage battery being charged. C. E. M. F. is the principal factor regulating the current taken by a motor or transformer. C. E. M. F. is not always or necessarily simply proportional to the strength of the current. Fall of potential is a more general term, including drop and C. E. M. F. Difference of potential is a general term and may refer to any of the others. Voltage is a general term similar to difference of potential, but in addition calling attention to the unit used in its measurement.

519. Can each of these quantities be measured?

All can be measured directly except C. E. M. F. and sometimes E. M. F. An electro-motive force can generally be measured by opening the circuit and connecting a voltmeter or its equivalent to the terminals of the source of current. When this cannot be done, the total E. M. F. equals the voltage at the terminals plus the ohmic drop through the generator. Likewise, C. E. M. F. is calculated by subtracting the ohmic drop from the voltage between the terminals.

520. How does Ohm's law apply to a circuit containing C. E. M. F.?

The C. E. M. F. may be considered as reducing the total E. M. F., and Ohm's law becomes: Current equals E. M. F. minus C. E. M. F. divided by resistance, or

$$\mathrm{I} = \frac{\mathrm{E.\,M.\,F.} - \mathrm{C.\,E.\,M.\,F.}}{\mathrm{R}}.$$

521. Give an example showing the effect of C. E. M. F.

A fifteen-horse-power street railway motor has a resistance of about one ohm. If resistance alone determined the current, this would take 500 amperes on a 500-volt circuit. As a matter of fact, the current varies from about 10 to 100 amperes. When the current is 20 amperes, the effective voltage or ohmic drop is 20, and the C. E. M. F. is the difference between 500 and 20, or 480 volts.

522. How can the drop on a line be calculated?

The drop equals the product of current by resistance, and therefore equals the product of current by length of wire by resistance per mil-foot divided by the square of the diameter, or for copper wire,

$$e = \frac{11 \times L \times I}{d^2} = \frac{11 \times L \times I}{\mathrm{c.\,m.}}.$$

When the outgoing and return wire are of equal length, the distance between the supply and demand is used instead of the length of the wire, the distance being taken as one-half the length of the wire. The formula then becomes, drop equals current multiplied by distance by twice the resistance per mil-foot divided by diameter squared or by circular mils, or,

$$e = \frac{22 \times D \times I}{d^2} = \frac{22 \times D \times I}{\mathrm{c.\,m.}}.$$

523. Give an example showing the calculation of drop on a line.

Suppose current of 100 amperes is carried from a dynamo to a motor 200 feet away by a copper wire having a diameter of 0.325 inch. The drop is

$$e = \frac{22 \times 200 \times 100}{325 \times 325} = \frac{440.000}{105{,}625} = 4.2 \text{ volts.}$$

Queries and Answers

IMPORTANT.—No attention will be given to inquiries which do not give the full name and address of the inquirer.

Why are repeating coils used to talk from grounded telephone circuits to metallic circuits? T. M. B.

In order to avoid actual contact between the two, which would ground the metallic circuit.

Is it advisable to install meters in a plant of 300 or 400 incandescent lamps? 2. What rate would you advise? N. N.

Yes. 2. That depends on the price of coal and conditions of operation, which you do not give.

What is the difference between reactance and self-induction? M. B. S.

Reactance is the result of self-induction expressed in ohms. Multiplying inductance (the coefficient of self-induction) by the frequency of alternations and by 6.2832 gives the reactance in ohms. Thus:

$$6.2832 \times \text{Frequency} \times \text{Inductance} = \text{Reactance.}$$

What change is necessary in the field connections of a 1000-volt two-phase alternator to enable it to supply a 2000-volt circuit? J. T. F.

None whatever. The only change necessary is to connect the armature coils up all in series instead of in two parallel groups. If they are already all in series the armature must be rewound for 2000 volts.

Why are gasoline motors preferred to kerosene motors for automobile work? (2). Is a carburettor indispensable to a gasoline motor? (3). Are there any compound gas or gasoline engines built? T. S. K.

Because the kerosene engine discharges more smoke and the jolting tends to disarrange the vaporizer. (2) No; but it secures more complete combustion. (3) Not commercially, so far as we know.

Why are the primary and secondary coils "sandwiched" in large transformers? 2. What is the leakage current of a transformer? L. G. M.

In order to reduce the magnetic leakage of lines of force in between the primary and secondary coils. 2. This term is erroneously applied to the exciting current of a transformer. The exciting current is that which is taken by the transformer when the secondary circuit is open; the work done by this current is to supply the energy wasted by core losses.

What is the best method of charging a storage battery for phonograph service in an isolated place? Can I use gravity batteries? K. V. Y.

If the phonograph is not used very often the storage battery can be kept charged by means of bluestone cells, using three bluestone cells to charge a single storage cell or five bluestone cells to charge two storage cells. An adjustable resistance should be provided if you have only one cell of storage battery as three bluestone cells are a little too strong and two are not strong enough.

What baths are used for silver and nickel plating? T. H. J.

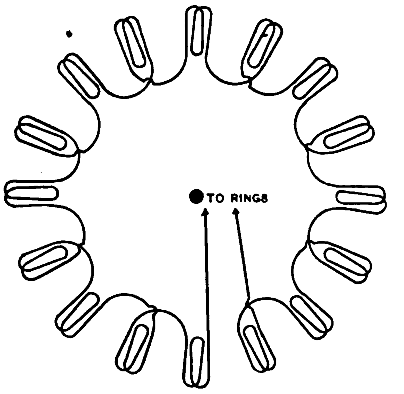
For a silver-plating bath dissolve 210 grains of nitrate of silver in a quart of water; add to this 350 grains of cyanide of potassium and shake the mixture and filter it; after filtering add a few drops of pure ammonia. For nickel-plating dissolve one part of double sulphate of nickel and ammonium in ten parts of warm distilled water, making the measurements by weight.

What limits the number of enclosed arc lamps that can be burned in series from a constant-potential alternating-current circuit? M. C. B.

The length of the arc and the voltage of the circuit. The e.m.f. at the terminals of an enclosed alternating-current arc lamp may be anywhere between 65 and 85 volts according to the length of the arc and the construction of the lamp. Dividing the e.m.f. of the circuit by the e.m.f. required at the terminals of the lamp will give the number of lamps which can be connected in series.

Can the armature coils of an ordinary alternator be connected up so that the current passes through all of them in the same direction? O. S. C.

This depends on the relation between the number of armature coils and the number of magnet poles. If the number of coils is the same as the number of poles then they must be connected up alternately forward and backward, as indicated by the accompanying sketch. If the number of coils is one-half the number of poles then all of the coils must be connected up in the same direction.



How can I determine the current per wire for a three-phase induction motor? For example, what size fuses would be needed for a 10-h.p. motor on a 550-volt three-phase circuit? C. A. G.

The current per wire in a three-phase motor circuit is found by the formula:

$$\frac{577 \times \text{kw.}}{E \times p \times e} = C.$$

In this formula "kw." is the output of the motor in kilowatts; "E" is the voltage of the motor; "p" is its power factor, and "e" its efficiency. A 10-h.p. 550-volt induction motor would probably have an efficiency of about 80 per cent and a power factor of about .85, so that the current required would be approximately two amperes for a single-phase motor or 1.15 amperes per phase for a three-phase motor.

Can the current of the secondary winding of an induction coil be measured in volts? I. B.

The voltage of the secondary winding of an induction coil cannot be measured by any ordinary means, as it is beyond the range of ordinary measuring instruments. It can be measured by a static voltmeter or estimated by the length of the spark. You will find in the Queries and Answers department of the May issue the e.m.f.'s corresponding to various spark gaps.

Knowing the voltage and number of watts delivered, how can I find the current per wire in a two-phase and three-phase circuit? P. R.

If the line is carrying a non-inductive load the current in each wire of a two-phase circuit is found by dividing the watts by twice the voltage. For a three-phase non-inductive circuit divide the watts by the voltage and multiply the quotient by 0.577; the result is the current per wire. For two-phase and three-phase circuits carrying inductive loads, as they usually do, the results obtained by the foregoing rule must be divided by the power factor of the circuit in order to obtain the actual current per wire.

What is the usual ratio between the indicated horse-power of an engine and the electrical output of the dynamo which it drives? J. G. F.

This depends upon the efficiency of the generator and that of the dynamo. It is common practice to instal an engine the indicated horse-power of which is from 1.6 times the output of the generator in kilowatts to twice that output, according to the size of the equipment; larger units being more efficient, require a smaller ratio than smaller units. The ratio can be computed for direct-connected units by means of the formula:

$$\frac{1.34 \times \text{kw.}}{E \times e} = \text{I. H. P.}$$

in which "kw." is the normal full load output of the dynamo; "E," its efficiency; "e," the mechanical efficiency of the engine, and "I.H.P.," its indicated horse-power at the most economical point of cut-off.

Why does the exhaust from an automatic high-speed engine make more noise when the engine is loaded than when it is running with a light load? N. E. R.

Because the pressure at which the exhaust steam is released is higher when the engine is driving a greater load; this is due to the fact that with the heavy load the governor cuts off the admission later in the stroke and the steam is not expanded to the same extent as when the engine is driving a lighter load, and the governor cuts off earlier in the stroke. For example, a simple engine with a clearance of 9 per cent, driving a load which necessitates taking steam up to half stroke, will have a terminal pressure of approximately 0.54 of the initial pressure and the same engine driving a load which permits cutting off at one-sixth of the stroke will have a terminal pressure of about 0.24, or less than one-half of the terminal pressure when the cut-off is at half stroke.

DUPLEX CYLINDER DRY CELL.

For a number of years past, electrical construction men, supply dealers, and others have been decrying the fact that the ordinary type of cylinder cell was hardly good enough for use in connection with electric bells, burglar alarms, etc., particularly as in most cases the contractor for such work is obliged to guarantee his installations for a period of twelve months. While there were one or two types of cells on the market that were satisfactory for this work, the price of the higher grade cells was too high to permit of their use on small installations of electric bells, etc. The National Carbon Company has recently placed a cell on the market that has been designed to meet these requirements, at the same time being low enough in price to justify its use on small contracts. This cell is known as the "duplex cylinder," the appropriateness of which name will be apparent on reference to the sectional view in Fig. 1. In external appearance the duplex cylinder is the same as the ordinary type. The walls of the cylinder, however, are hollow and the annular space in the walls is filled with a depolarizing compound, there being sufficient depolarizer to consume two or three pencil zincs. Figs. 2 and 3 give a comparison between the performances of a duplex and of an ordinary cylinder during and subsequent to a short-circuit. The solid lines apply to the duplex cylinder cell.

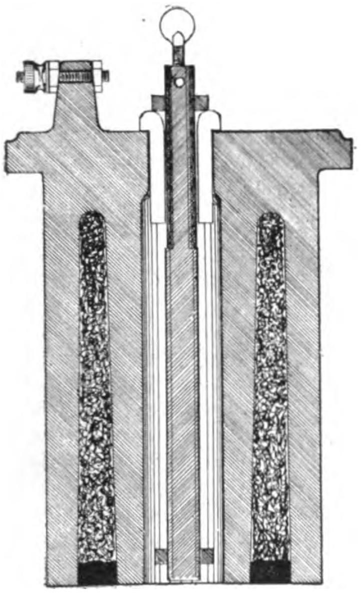
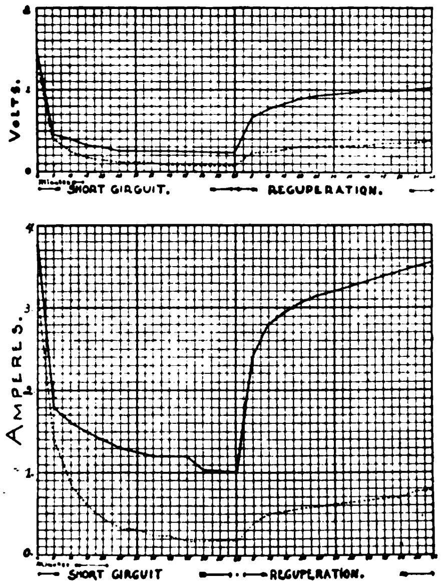


FIG. 1.—SECTION THROUGH CYLINDER.



FIGS. 2 AND 3.—COMPARATIVE CURVES.

The chemical reaction occurring in this cell is undoubtedly that accepted for all carbon and zinc cells in which black oxide of manganese is used as the depolarizer. The reaction, according to Carhart, is as follows.

$$Zn_x + 2NH_4Cl \,\|\, 2MnO_2 + C_x = Zn_{x-1} + ZnCl_2 + 2NH_3 + Mn_2O_3 + H_2O + C_x,$$

but, unlike some cells containing depolarizer, it is evident that a different condition is reached in the "duplex" cell. This condition is the location of the depolarizing material between the carbon element and the zinc. That this condition is obtained seems to be evident from an analysis of the curves; during the first five minutes of discharge the characteristics of the curves for both the ordinary and "duplex" types are essentially the same. After five minutes' short-circuit, it would seem that the inner wall of the duplex is put out of service, undoubtedly through its becoming polarized and the action then takes place between the zinc and the inner surface of the outer wall of the cylinder. The depolarizer consists of a mixture of three substances, one of them being black oxide of manganese (MnO_2). The mixture is one developed by the National Carbon Company after several years of study, and seems to give better results than the broken carbon and manganese depolarizer commonly used.

THE JONES UNDERFEED STOKER.

One of the prime requirements of a mechanical stoker is simplicity; another condition which it is of importance to secure is the isolation from the influence of the furnace heat of just as many of the moving parts as possible. There are, of course, other essentials, such as the complete coking of the fuel and combustion of the distilled gases, but even though these be assured under normal conditions of operation, the stoker cannot work satisfactorily if it comprises complicated mechanism subjected to the terrific temperature of a furnace. These considerations, together with a firm belief in the efficiency of feeding the fuel to the fire from below, led to the production of the Jones underfeed stoker illustrated herewith.

Fig. 1 shows the stoker complete; Fig. 2 gives a cross-sectional view of it in position, and Fig. 3 is a view into the retort. The moving parts consist of a piston within a steam cylinder; a plunger or ram to force the coal into the retort; a piston rod connecting the piston and plunger, and a set of auxiliary conveyor blocks which receive a reciprocatory motion through a push rod and links from the plunger. The hand lever shown in Fig. 1 serves to actuate the steam valve to admit steam to either end of the cylinder or shut it off, as required. It is evident that no moving parts are exposed to the heat of the furnace. A lever and link are also provided, when stokers are installed in gangs, which may be used to connect

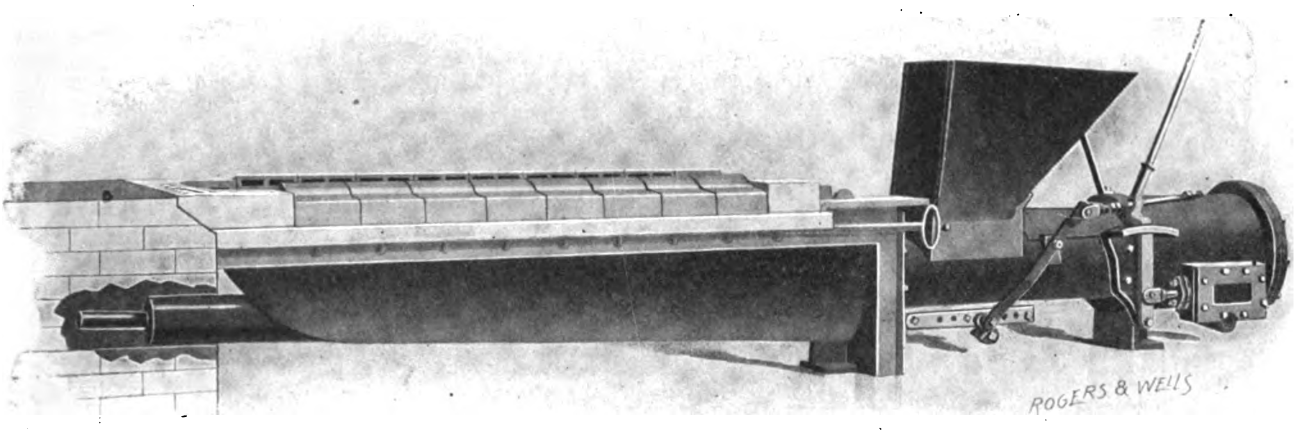


FIG. 1.—THE IMPROVED JONES UNDERFEED MECHANICAL STOKER.

the plunger with the valve lever, making the stoker automatic. On single stokers this attachment is not used, as it is considered preferable to compel occasional attention by requiring the valve lever to be operated by hand.

Air is admitted to the furnace through tuyere blocks located along the edges of the retort, as shown in Fig. 3, the air being supplied by a blower fan. The tuyere openings are above the green fuel in the retort, but below the fire, so that the entering air may mix with the gases from the coking fuel and support combustion. The tuyere blocks are held in place each by an eye projecting from the bottom of the block; the openings in these eyes are in line and a rod is threaded through all of the eyes on one side and another rod passes through the eyes on the other side of the retort. The ends of these rods which project out into the fireroom are formed into handles; these handles show plainly in Fig. 3. The two rods also pass through holes in the framework, so that when they are in place the tuyere blocks are all locked in; pulling out a rod releases all of the tuyere blocks on that side of the retort.

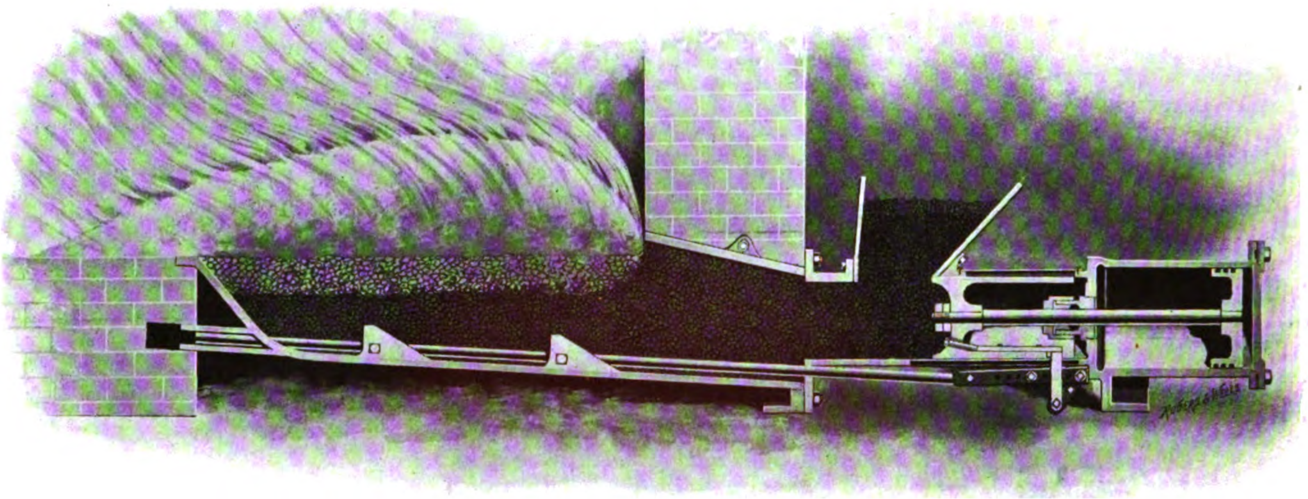


FIG. 2.—LONGITUDINAL SECTION THROUGH STOKER IN OPERATION.

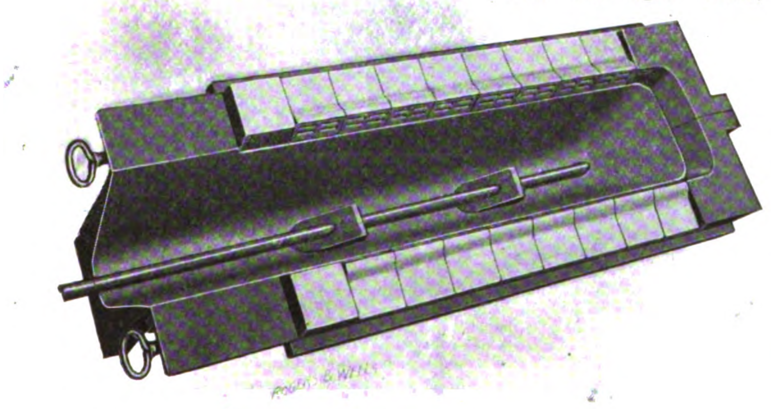


FIG. 3.—RETORT AND TUYERE BLOCKS.

The incombustible portion of the fuel that remains in the retort is forced upward by the incoming supply of coal and out upon dead plates on each side of the retort. It is stated by the builders that the furnace is smokeless by reason of the fact that the mixture of air and distilled gases is so thorough as to insure almost complete combustion, with a negligible amount of carbon monoxide in the flue gases.

A NEW SCHEEFFER WATTMETER.

The Diamond Meter Company, Peoria, Ill., has brought out an improved type of Scheeffer recording wattmeter known as Type E, and represented by Fig. 1 herewith. One great trouble in previous motor meters has been the deterioration of the jewel and bearing caused by the weight of the moving member, and the vibration due to alternating current of considerable strength. While this may not affect the full-load accuracy of the meter, it causes the instrument to lose its sensitiveness because of the increased friction of its bearing, and to slow on light loads, or even not to register. Mr. Scheeffer has overcome the difficulty very simply by first making the moving element very light (it consists of a thin aluminum disc with a shaft of light brass tube, the whole weighing but twelve grams) and secondly by resting this moving element on a hardened and highly polished steel ball contained in a sapphire cup. The advantage of this form of bearing is that the steel ball is self-centering and can be quickly replaced by a new one in connection with the jewel, giving the meter a new bearing without any change or even disturbing the full-load calibration; another feature tending to minimize wear is that the disc is subjected to so light a force from the shunt winding that it is free from vibration.

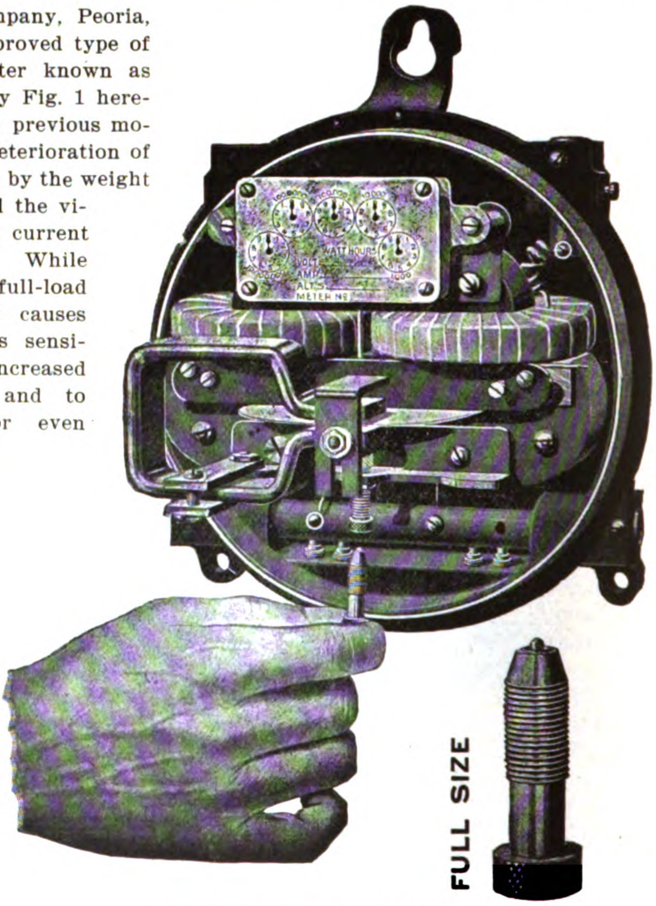


FIG. 1.—SCHEEFFER WATTMETER.

The laminated iron magnets excited by

the shunt coils are so constructed that the magnetic flux from them is mostly shunted through an iron mass, a very small proportion passing through the disc. As the total power consumed by the shunt magnets is about one watt, and only one-twentieth of the flux is allowed to pass through the disc, the latter is subjected to only one-twentieth of one watt, or a trifle less, as the iron absorbs a part of the exciting power by hysteresis. The result of these various features is that the bearing remains almost frictionless indefinitely. Fig. 1 shows the manner of taking out the ball and jewel for inspection or replacing, and also shows the complete bearing step full size.

The series coil, which carries the full current, consists of only a few turns of thick wire and is coreless; the voltage drop through it is too small to be ordinarily measured, as the total loss in the meter at full load is only two or three watts, according to the size; this admits of the meter being overloaded 50 per cent without impairing its accuracy. The meter responds quickly to sudden changes in load because of the light weight of its moving element, and this also makes it extremely sensitive; a meter of ordinary size is said to register correctly a 2-c.p. lamp. The meter is direct reading, no constant being necessary, and it is said to be accurate on both inductive and non-inductive loads. The weight complete has been reduced from 18 to 11 pounds, with a sheet-metal case. The meters are usually furnished with sheet-metal cases to keep down the weight, but cast-iron cases are furnished when desired; this will add one or two pounds to the weight. The meter is sealed at the factory and is ready for installing without any adjustment; all connections are on the outside and it is not necessary to open the meter. The cases are made dust-proof and bug-proof.

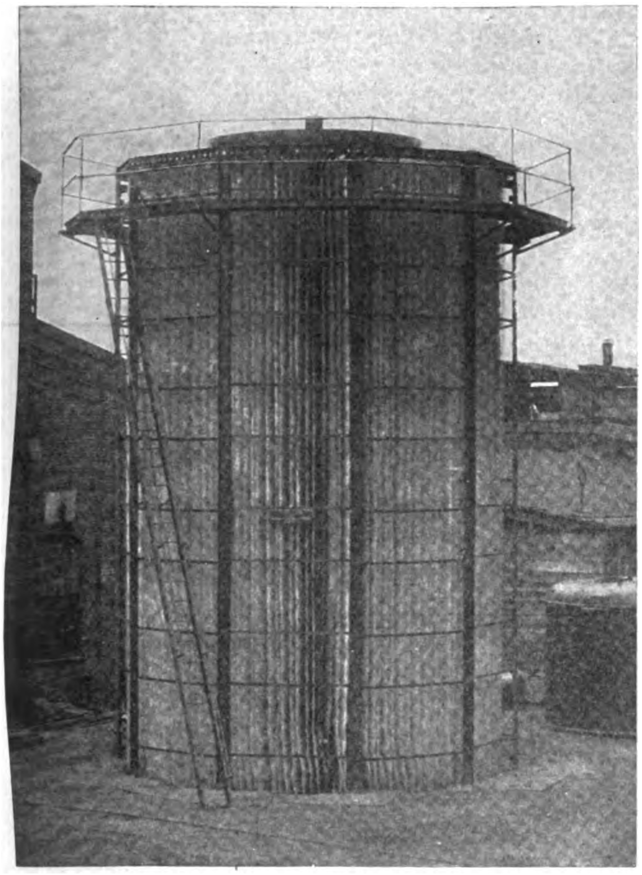


FIG. 1.—1000-H.P. FANLESS COOLING TOWER.

FEED-WATER PURIFIERS AT THE DEERING HARVESTER PLANT.

In the article descriptive of the motor equipment of the Deering Harvester Works, published in the August number, it was stated that "Hoppes live-steam feed-water purifiers, aggregating 2500 horse-power, are used to avoid the introduction of oil into the feed water." We are advised as a matter of fact that there are 5000 horse-power of Hoppes purifiers at the Deering Works, 2500 horse-power in the twine mill and 2500 horse-power in the new steam plant, and these are used for general purification of the feed water; the oil is also eliminated but the main consideration is the removal of scale-making solids from the feed water.

BARNARD FANLESS COOLING TOWER.

The Barnard cooling tower in connection with which a fan blower is employed for the purpose of air circulation is familiar to steam users generally, and its advantages are generally known and appreciated. The designer of this apparatus has gone a step farther and produced the Barnard fanless cooling tower shown by the accompanying illustrations. The principle of construction is the same as in the older type of Barnard tower; wire cloth mats are provided upon which the water is sprayed from perforated and slotted pipes. The mats radiate from the center, and their outer edges form a generally circular outline; there is no outer shell as in the fan tower, the mats being exposed freely to the air.

The water-distributing pipes are arranged in sections so that the amount of active piping and cooling surface may be varied to correspond with variations in the engine load. This arrangement is also convenient in cleaning the mats, as a small section can be cut off and cleaned while the remainder of the tower is in service. The hot water from the condenser is pumped up to the top of the tower through a pipe in the center of the structure; thence it passes to a trough and the distribution pipes which deliver it to the cooling mats. The water trickles down the mats to a reservoir tank at the base of the tower, whence it is taken to the condenser for service again. It is evident that the only energy required by this cycle is that necessary to raise the water from the base of the tower to the top. Should the tower be located on a roof, which its light weight renders entirely feasible, the energy expended in pumping water up to the base of the tower is approximately regained in the gravitational descent of the cooled water from the reservoir tank.

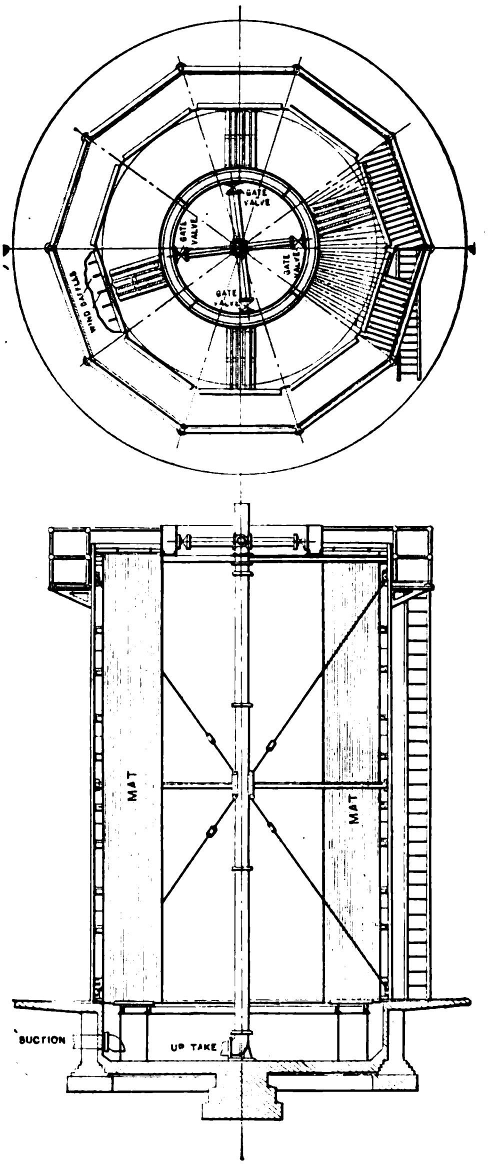


FIG. 2 —DETAILS OF TOWER STRUCTURE.

The remarkable simplicity of the apparatus is an especially strong point in its favor, particularly for central station service where considerable complication in other directions is inevitable and where, consequently, any additional complication is highly undesirable. As regards efficiency, it is stated that a common result is the reduction of condensing water temperature from 135° to about 90° or less. The usual height of the fanless tower is about 30 feet, and its weight per square foot of foundation area is very low, making it available for roof service. The half-tone illustration herewith shown represents a 1000-h.p. tower.

New Apparatus and Appliances

COLUMN TYPE METERS.

After several years of experiment the Whitney Electrical Instrument Company has perfected a peculiar and somewhat radical type of indicating and recording meter, the operation of which is based upon the variation of air pressure in a closed vessel, which is indicated by the rise and fall of a column of non-volatile liquid in a glass tube and controlled by variations in the current to be measured.

Fig. 3 is a cross-section of an indicating meter and Fig. 4 is that of a recording meter. A perspective view of the recording meter is shown by Fig. 1. Referring to Fig. 3, air is delivered at a fairly constant pressure of about 1¾ lbs. per square inch through the pipe, A, to the chamber, B, from which it flows through a series of porous diaphragms, C, made of filter paper, the functions of which are to serve as an air resistance and to remove any particles of dust. After filtering through the porous diaphragms the air enters the passage, D, which communicates with a closed chamber, N, containing liquid and communicating with a glass tube, O. The passageway, D, is also provided with a vent, E, which is normally closed by the valve, F, held down through the medium of the pin, H, by a spool of wire, J. This spool is mounted on the end of a lever, I, hung at L, and carrying a counterweight, K, by means of which the downward pressure due to the coil, J, can be adjusted. The current to be measured passes through the coil, J, connections to which are made at the suspension, L, which consists of two short thin copper pieces.

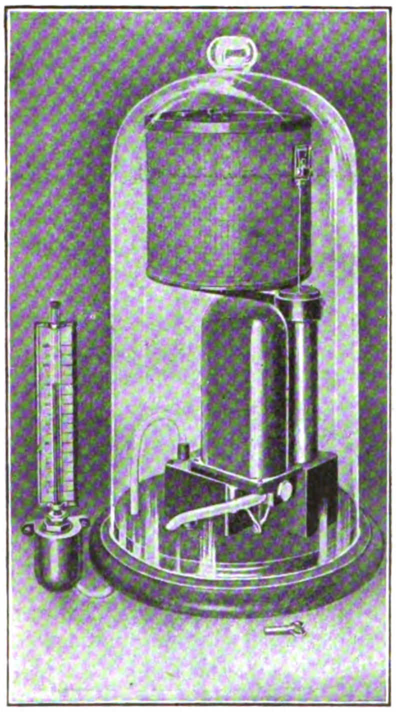


FIG. 1.—RECORDING METER.

The magnet, M, furnishes the field and the current goes through the coil, J, in such a direction that there is repulsion between it and the magnet, M, increasing the downward thrust of the pin, H, on the valve, F, according to the amount of current flowing. The counterweight, K, is adjusted so that when there is no current in the coil the pressure on the valve, F, is such as to maintain just sufficient pressure in the passageway, D, and chamber, N, to force the liquid in the latter chamber up to the point, R, which is the zero of the scale. Should the air pressure delivered into the chamber, D, exceed this amount it simply raises the valve, F, until the pressure within is equal to the pressure upon that valve. It will be obvious that increasing the current in the coil, J, will increase the air pressure in the passageway, D, and the chamber, N, causing the fluid to rise in the tube, O, which is calibrated to indicate by the level of the liquid the amount of current in the coil or the voltage of the circuit, according to whether the instrument is intended for current or potential indication.

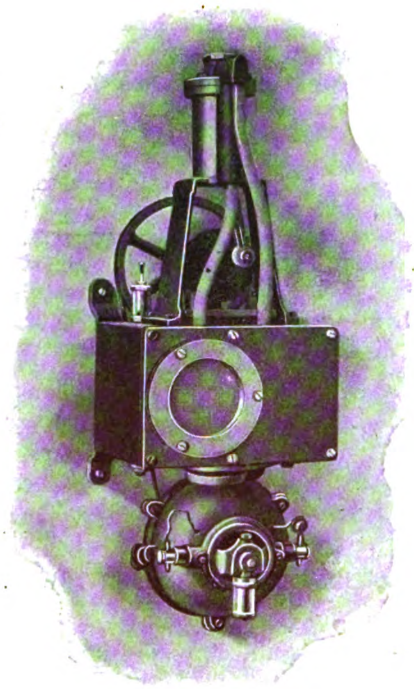


FIG. 2.—AIR COMPRESSOR.

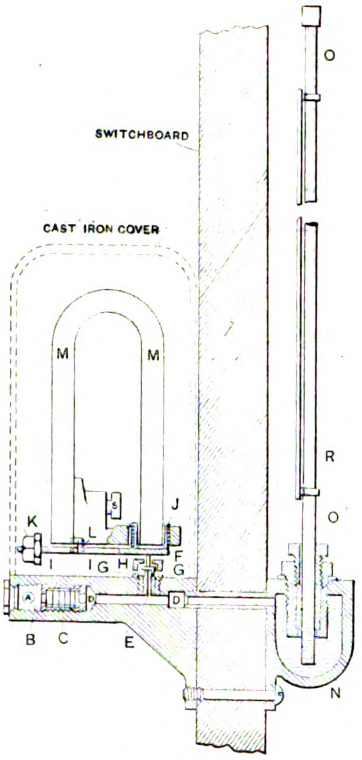


FIG. 3.—INDICATOR.

An iron screw, S, of heavy cross-section serves to calibrate the magnet, M, its adjustment back and forth giving a variable magnetic shunt across the poles of the magnet. The left-hand pole of the magnet is provided with an extension which surrounds the coil, J, and localizes the field. The total movement of the coil, J, up and down is extremely small, being less than 1/100 of an inch, and the only work that it performs is evidently that of controlling the air pressure, which is reduced to an insignificant amount by making the area of the vent, E, small.

The recording instrument shown by Figs. 3 and 4 differs from the indicating instrument only in being provided with a larger reservoir and tube, O, the latter containing a float, P, which through the medium of the rod, Q, moves a pen up and down across the face of a revolving drum. This instrument is also provided with an indicating attachment exactly like that on the indicating meter, the chamber, U, Fig. 4, taking the place of the chamber, N, Fig. 3. This instrument has the very great advantage of being separable; the indicating portion may be put on the switchboard and the mechanism and recording drum locked up in a closet or put in the superintendent's office. Moreover, any reasonable number of in-

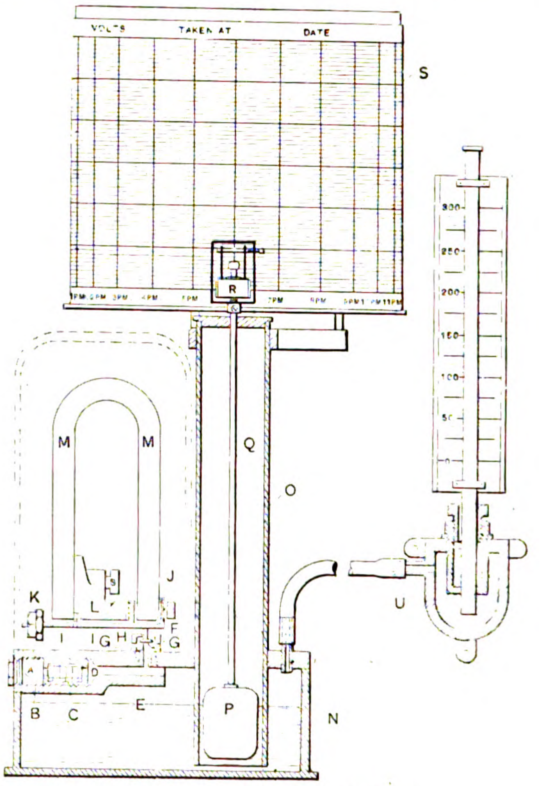


FIG. 4.—RECORDER AND INDICATOR.

dicating attachments may be used in connection with a single recording instrument.

The air pressure necessary to actuate the indicating and recording portions of the instrument may be obtained from any suitable source, but the company supplies two types of air compressor for this purpose. One is a simple single-cylinder air pump mounted on a square iron box which serves as a reservoir and driven by a 1/20-h.p. motor suspended beneath the reservoir and connected to the pump by means of a round belt. This little machine is said to supply sufficient air to operate 50 indicating meters or 12 recording meters, the latter requiring nearly four times as much air as the former, as will be evident upon a comparison of the two structures. The motor is furnished for either 110 or 220 volts pressure and to operate on either direct or alternating-current circuits. The second type of air compressor is a hydraulic machine which operates like an injector, a water jet carrying air along with it and compressing it to the desired pressure. These compressors require about 10 gallons of water per hour for each instrument, with a 3-ft. head.

DESHLER-MCALLISTER PHOTOMETER LAMP ROTATORS.

The accompanying engravings, Figs. 5 and 6, illustrate respectively the electric-motor lamp rotator and spring-motor lamp rotator manufactured by the Electric Motor & Equipment Company, Newark, N. J., for use in connection with the well-known Deshler-McAllister photometers. These pieces of apparatus are extremely simple in construction. The electric rotator comprises a small electric motor which is designed for use on either direct-current or alternating-current circuits of 50 to 120 volts e.m.f.; the motor will also operate on alternating-current circuits of any of the standard frequencies, and the speed of the machine is practically the same on any circuit, being such as to give the lamp a speed of 180 r.p.m. The spring motor is very compactly built and runs for 30 minutes with one winding; by giving the key an occasional turn, however, the motor may be kept running continuously. In both forms of rotator the stand is provided with mercury contacts instead of collector rings and brushes in order to avoid liability to the introduction of varying resistance in the testing circuit.

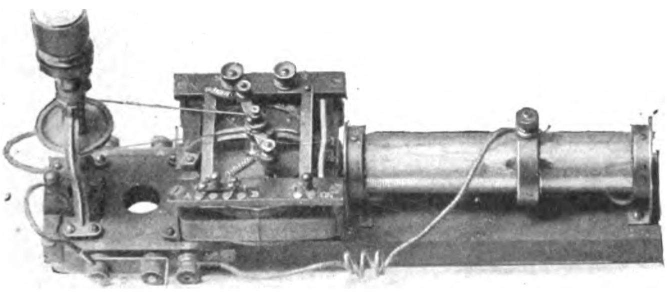


FIG. 5.—ELECTRIC MOTOR ROTATOR.

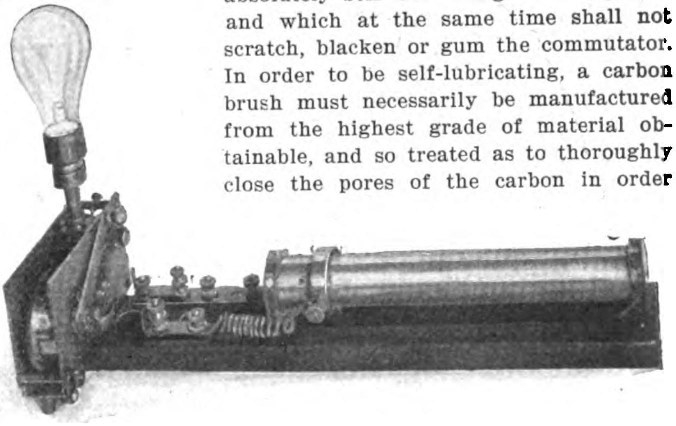


FIG. 6.—SPRING MOTOR ROTATOR.

THE FISHER CABLE TESTING SET.

With an increasing use of both overhead and underground cables for telephone, electric light, power and other service comes a corresponding demand for apparatus to test the qualities of these cables, viz.: inculation, capacity and resistance. One of the most recent instruments for this purpose is the Fisher cable testing set illustrated by Fig. 7. This apparatus was designed by Henry W. Fisher, Chief Engineer of the Standard Underground Cable Company, and results from long experience in work of the character indicated. The most prominent feature of the instrument is a "master" switch by means of which connections are automatically changed from one class of measurements to another, rendering it possible for the operator to make rapid and accurate tests whether in a laboratory or out of doors. Any one who has had experience in cable testing will appreciate the great value of this freedom from the considerable number of connecting wires which under ordinary conditions must be changed whenever it is desired to test insulation or ordinary resistance, as well as capacity. The component parts of the Fisher set are a standard condenser of multiple-series type, with a range of from 0.02 to 0.5 microfarad; a resistance of 100,000 ohms, in two coils, one of 30,000 and one of 70,000 ohms; a Wheatstone bridge and resistance box of the "Decade" or "Post Office" pattern; a horizontal D'Arsonval galvanometer; an Ayrton universal shunt; a special "master" switch; short-circuit and other keys; galvanometer and battery reversers, and a dry battery of 10 cells. The whole set is compactly mounted in a handsome carrying case, the lid of which is removed when tests are to be made. For ordinary requirements the outfit is complete in itself, but for measuring high insulation or capacity it is desirable to use a separately mounted high sensibility D'Arsonval galvanometer and an independent battery of 50 or 100 cells. The apparatus is manufactured by Morris E. Leeds & Co. and sold through their general selling agent, James G. Biddle, of Philadelphia.

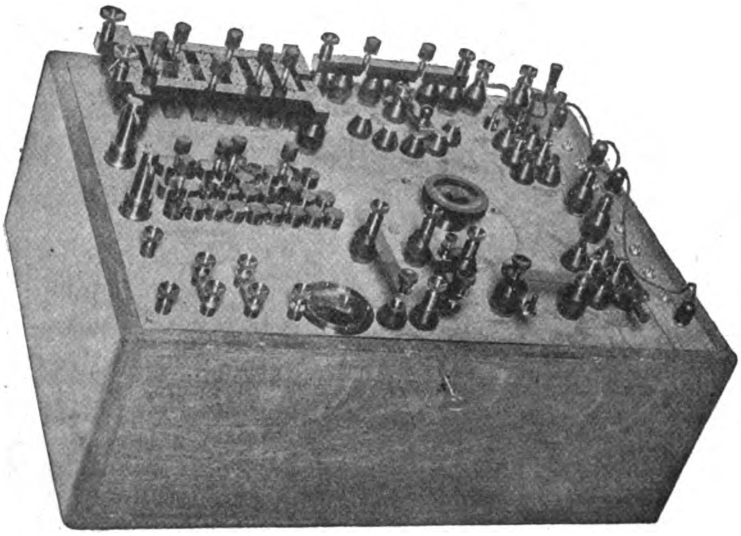


FIG 7.—FISHER CABLE TESTING SET.

AN IMPROVED LONG-LIFE CARBON BRUSH.

Much experiment and considerable sums of money have been devoted to efforts to produce the carbon brush which shall be absolutely self-lubricating and long-lived and which at the same time shall not scratch, blacken or gum the commutator. In order to be self-lubricating, a carbon brush must necessarily be manufactured from the highest grade of material obtainable, and so treated as to thoroughly close the pores of the carbon in order that the contact surface of the brush will itself attain and impart to the commutator the high polish required for good service and the absence of sparking and cutting. At the same time the resistance of the brush must not be increased by the treatment referred to, but should be lowered in order to minimize the heat loss. A brush which is claimed to fill these requirements has recently been perfected and put on the market by the Speer Carbon Company, St. Marys, Pa. This brush is said to have a very low resistance and to be free from crumbling and chipping; while the contact surface takes a high polish, it is claimed that it will not scratch the commutator; on the other hand, it supplies continuous lubrication without gumming or blackening.

STURTEVANT ENCLOSED MOTOR.

The enclosed motor shown by Fig. 9 is built by the B. F. Sturtevant Company of Boston, Mass., and is furnished in the form shown for ordinary power purposes and also direct-connected to propeller fans, one of which has been previously described in this paper. The motor is a bipolar machine; the field-magnet ring is made sometimes of wrought iron and sometimes of cast iron, according to whether the weight of the motor is an important consideration or not. The field-magnet cores are wrought iron and are bolted to the magnet ring; the cores have cast-iron pole-pieces riveted permanently to them. The armature core is of the usual slotted type; the slots have parallel sides, and the winding is wound directly on the core.

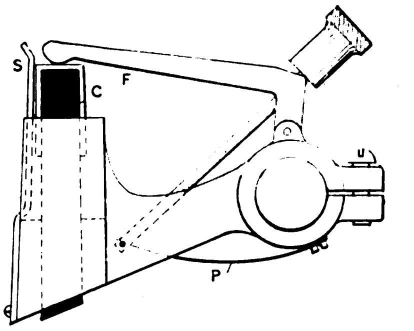


FIG. 8.—STURTEVANT BRUSH HOLDER.

The brush holder is an extremely efficient modification of the reaction type, and is illustrated by Fig. 8, which is almost self-explanatory. As the cut shows, the finger, F, which forces the brush forward, receives its pull from a heavy phosphor-bronze spring, P, the tension of which is adjustable by the knurled thumb-nut. The back end of the brush carries a brass yoke, C, against which the finger, F, presses. One side of this yoke slides against the flat phosphor-bronze spring, S, which prevents chattering and helps to carry the current from the brush holder to the carbon. The holder is clamped to the brush rod in the usual manner, as indicated in the engraving.

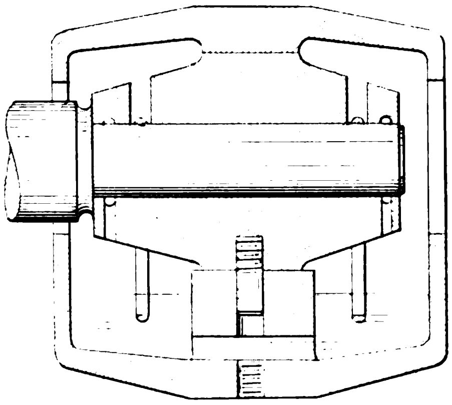


FIG. 10.—STURTEVANT JOURNAL BOX.

The bearings are of the self-oiling marine type; a cross-section of one is represented by Fig. 10, which shows that two oiling rings are used in each box. The bushings of the boxes are of composition, and may be removed from the outer ends by taking out the retaining screw, without dismantling the motor or taking out the journal yoke.

The holes in the end plates of the motor are closed by hat-shaped caps, one of which is shown on the floor beside the machine in Fig. 9. These caps are not bolted in place but are held by small spring clips which project beyond the periphery of the cap and disc and pass through two slots in the edges of the opening, the cap being given a partial turn after the springs are inside.

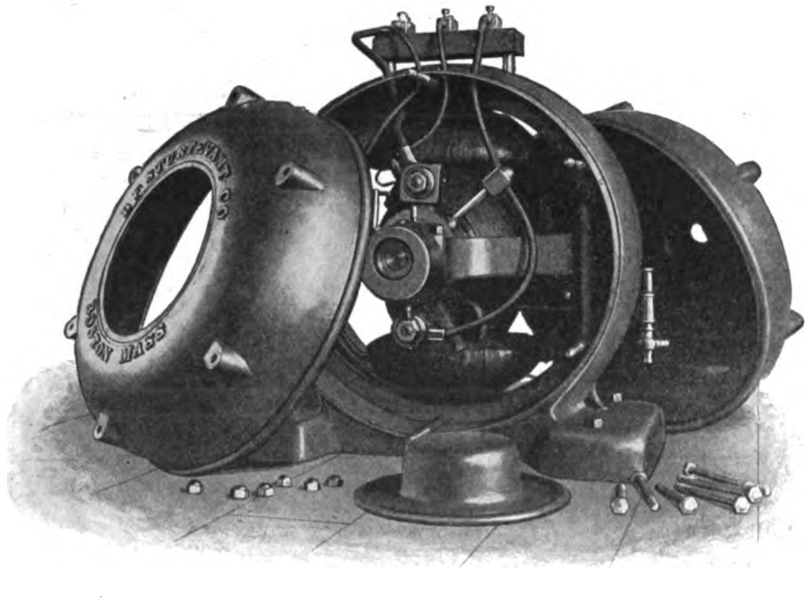


FIG. 9 —STURTEVANT ENCLOSED MOTOR; BIPOLAR TYPE.

The machine is said to be capable of continuous operation for 10 hours with a temperature rise not exceeding 60° F. These machines are built in sizes from 1/6 to 5 horse-power.

PARAGON MOTORS.

An unusually complete line of small motors has been designed and put on the market by the Paragon Fan & Motor Company, New York City; one of these is represented by Fig. 11. The line ranges from 1/20 horse-power to 1½ horse-power, and is divided into three series, designated L, M and H. Series L includes low-speed motors of from 1/20 to ½ horse-power; series M comprises moderate-speed motors of from 1/16 to 1 horse-power, and series H ranges from 1/12 horse-power to 1½ horse-power, designed to run at ordinary speeds. All of the motors are bipolar and iron-clad, with a single-piece cast-iron field magnet.

The engraving shows an inverted ceiling motor, but the machine may be mounted on the side of a post or on the floor in the usual manner. In order to remove the armature it is only necessary to remove two nuts on the back of the machine which are screwed onto the ends of bolts extending from the front journal yoke through the field structure; this leaves the journal yoke free to be withdrawn, after which removing the pulley from the shaft leaves the armature free for removal. The field coils are form-wound, taped with linen and dipped in a special insulating varnish, after which they are thoroughly baked. The armature coils are hand wound in slots partially covered by overhanging teeth, and are thoroughly insulated with mica and heavy paper. After winding, the armature is dipped and baked like the field coils; the overhanging teeth render the use of binding wires unnecessary. The journal boxes are so designed that they may be rotated within the journal yoke so that it is not necessary to take off the yoke in order to change the motor from one style of mounting to another; simply twisting the journal boxes one-quarter or one-half a revolution being all that is necessary. The brush holders are mounted directly in the

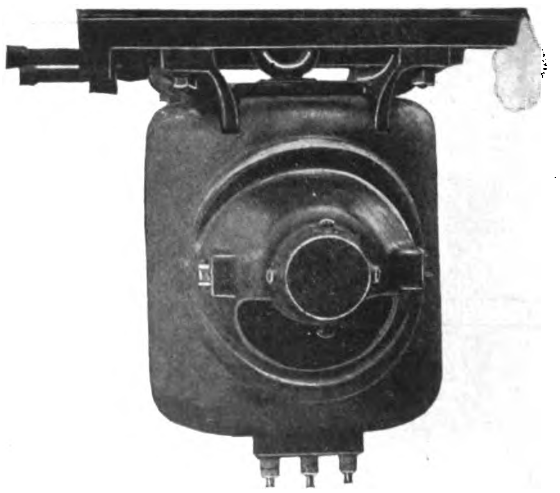


FIG. 11.—PARAGON MOTOR.

sides of the journal yoke, no brush quadrant being necessary because the brushes do not require adjustment. Self-feeding carbon brushes are employed, of course, and the brush holder is of an unusually compact and efficient design.

Type	M 1	M 2	M 3	M 4	M 5	M 6
Horse-power	1/16	1/8	1/6	1/4	1/2	1
Max. Temp. Increase 10 hrs., 10% Overload	45° C	43° C	40° C	35° C	37½° C	36° C
Field loss, watts	11	12	15	22	26	43
Armature loss, free	6	10	17	24	40	65

The efficiency curves shown in Fig. 12 indicate the excellence of the design of these little machines; it will be noted that the M-6 machine, the output of which is a horse-power, has an efficiency at full load of nearly 85 per cent, and the M-3 machine, the output of which is 1/6 horse-power, has the very high efficiency of 76 per cent. The curves also show that most of the machines are rather underrated. The accompanying table presents interesting data concerning the copper losses and rise of temperature of the class M machines. The motors are furnished, if desired, with an auxiliary shield which covers the opening shown below the commutator in Fig. 11, making the machine totally enclosed.

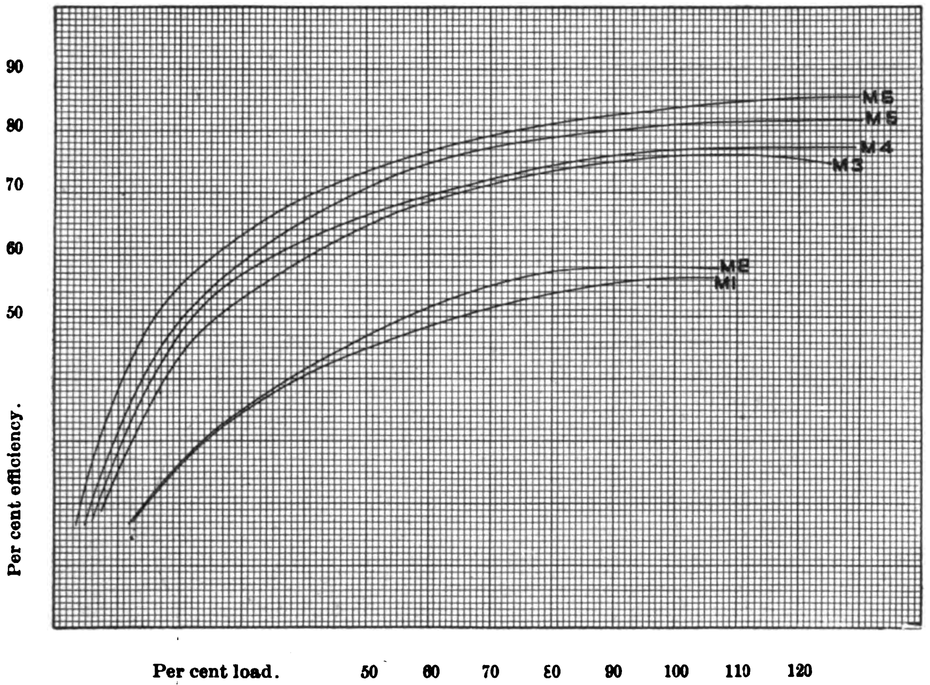


FIG. 12.—EFFICIENCY CURVES OF PARAGON M-6 MOTORS; SIZES RANGING FROM 1/16 H.P. TO 1 H P.

REYNOLDS AUTOMATIC STEAM TRAP-SEPARATOR.

Fig. 13 gives a cross-sectional view of an automatic steam trap-separator patented by W. H. Reynolds of Galveston, Texas, and manufactured by the Dickson Car Wheel Company, Houston, Texas. The baffle plate, B, intercepts the steam entering the inlet, and the moisture trickles down the baffle plate into the water chamber of the trap, while the steam passes over the top. The feature of the device is the method for automatically disposing of the condensed water. As the water rises in the lower chamber it also rises in the cylinder, C, and raises the float, F, when the latter becomes about two-thirds submerged. When the water level rises beyond a predetermined height the float, F, is raised until the port in the valve, V, attached to its upper end comes opposite the opening of the pipe, S, establishing communication between the upper part of the water chamber and the pipe, S, by way of the upper connecting pipe, p, the channel in the stem at the upper part of the float, F, and the passage and port in the valve, V. The exhaust steam then passes from the upper part of the separator through the pipe, S, and down to the small cylinder, c, forcing the piston, P, over to the right and opening the valve, v, thereby establishing communication between the bottom of the water chamber and the discharge pipe, D. The area of the piston, P, is much larger than that of the valve, v, attached to its stem, so that although the valve, v, is exposed to the same pressure per square inch from the water chamber as the pressure on the piston, P, the piston and valve will be driven over to the right because of the larger area of the piston. The bore of the lower pipe, p, leading from the vertical cylinder, C, into the water chamber is much smaller than the bore of the passageway from the bottom of the water chamber to the discharge pipe, D; consequently the water will leave the water chamber more rapidly than it does the vertical cylinder, C, so that the chamber will be drained before the float, F, falls sufficiently to close the port in the valve, V, and open communication between the pipe, S, and the exhaust outlet, E. When the float falls to this level, where it is shown in the cut, the steam pressure in the pipe, S, is relieved and the pressure in the water chamber forces the valve, v, and the piston, P, back into the position shown, cutting off the communication between the water chamber and the discharge pipe, D; all the parts remain in this position until the water level rises in the water chamber, as above described, when the cycle is repeated. While the automatic arrangement just described is the principal feature of this separator, it is also supplied separately and may be attached to any other make of separator.

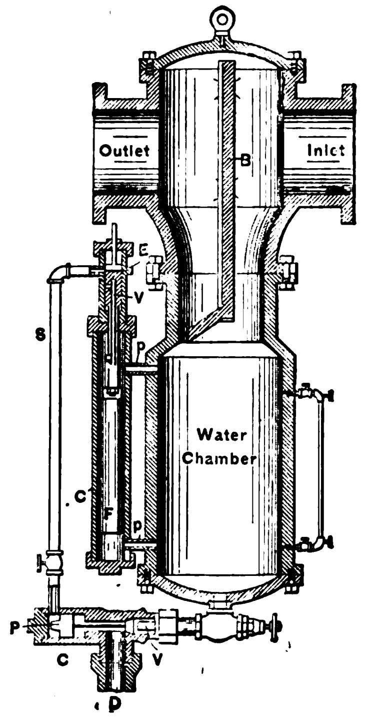


FIG. 13.—SECTIONAL ELEVATION OF REYNOLDS STEAM TRAP-SEPARATOR.

STOCKER COOLING TOWER.

Fig. 14 illustrates a double-fan cooling tower built by Geo. J. Stocker, of St. Louis, Mo. One of the features of the Stocker cooling tower is the employment of two blower fans situated one on each side of the base, which is claimed to secure a better distribution of air throughout the interior of the tower and to require less driving power for a given amount of air discharged. The tower itself consists of a strong wooden casing

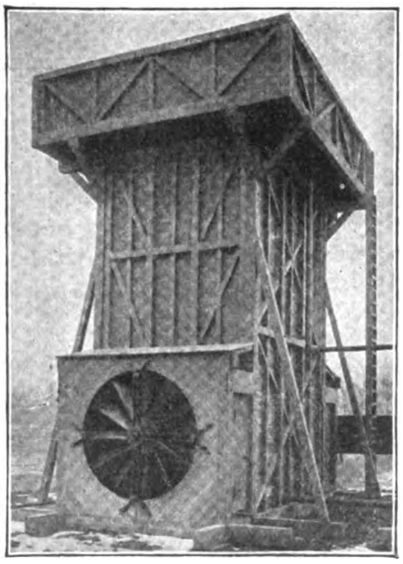


FIG. 14.—STOCKER DOUBLE-FAN COOLING TOWER.

provided on the interior with a checker-work of boards in horizontal layers, disposed at right angles to each other and provided with vertical partitions set obliquely across the open spaces between the intersections. The hot water is distributed at the top of the tower through a system of funnel-shaped troughs and trickles down the vertical partitions and through the checker-work referred to, being thoroughly exposed to the cooling action of the ascending air. It is claimed that the temperatures obtained by the construction employed in this tower are considerably lower than those usually observed. The manufacturer manifests his own faith in his apparatus by offering to make his compensation dependent upon the amount of saving effected by the tower.

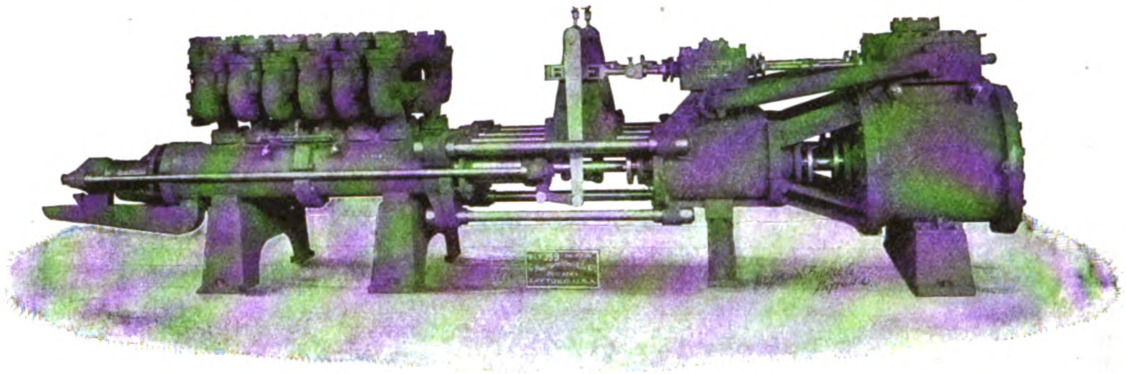


FIG. 15.—SMITH-VAILE COMPOUND DUPLEX PRESSURE PUMP; POT VALVE STYLE.

A NEW COMPOUND DUPLEX PRESSURE PUMP.

The Stilwell-Bierce & Smith-Vaile Company, Dayton, Ohio, has brought out a new compound duplex pressure pump to develop a maximum pressure of 700 pounds per square inch, of which Fig. 15 is an illustration. The liquid end is of the end-packed trombone style; the cylinders are made of a special metal, and separate chambers are mounted on the cylinders for the reception of the valves. These valve chambers are also built of special metal and are designed with a view to providing quick access for the inspection of the valves. The valves are of the hydraulic pattern, made of steel, and guided from below. An extension piece is provided for supporting the water plunger, and an approved adjustment device provided therefor. The water end of the pump is mounted on heavy supporting columns. An engine of the transposed cylinder type is furnished, the design of which is such as to give free access to all steam pistons without dismantling the pump. The outside valve adjustment is a feature of the pump.

JEANESVILLE TRIPLEX SINKING PUMP.

Fig. 16 illustrates a new triplex sinking pump for mining service, driven by an electric motor, and built by the Jeanesville Iron Works Company, Jeanesville, Pa. The pump is provided with three single-acting plungers driven from a crank shaft after the usual method adopted in triplex pumps, the shaft being double-geared to the motor. The water cylinders are cast in a single piece and connected to the guides by means of hollow castings which form a vacuum chamber on one side and an air chamber on the other side. Each plunger is cast on end from hard, close-grained pig iron, and is bolted to a cross-head guide fitted with adjustable bronze shoes. The connecting rods are provided with adjustable bronze boxes at each end. The crank shaft is of the best open-hearth steel and, as previously noted, is driven through double-reduction gearing. There is a gear at each end of the crank shaft, the countershaft which is geared to the motor extending across to the motor structure and carrying two pinions which mesh with the gears on the crank shaft. All of the gearing is machine cut and designed on the basis of an unusually liberal factor of safety in order to assure reliability of operation. As the illustration shows, the machine is entirely enclosed, but the running parts are easily accessible by removing the plates which close the openings of the frame. The pumps are built in four sizes, ranging from 65 to 150 gallons per minute, and designed to work over a maximum lift of 350 ft. All of the bearings are adjustable for wear and the pumps are provided with complete priming valves. The motor is of a special iron-clad design built by the Crocker-Wheeler Company, and is furnished for any of the standard direct-current voltages.

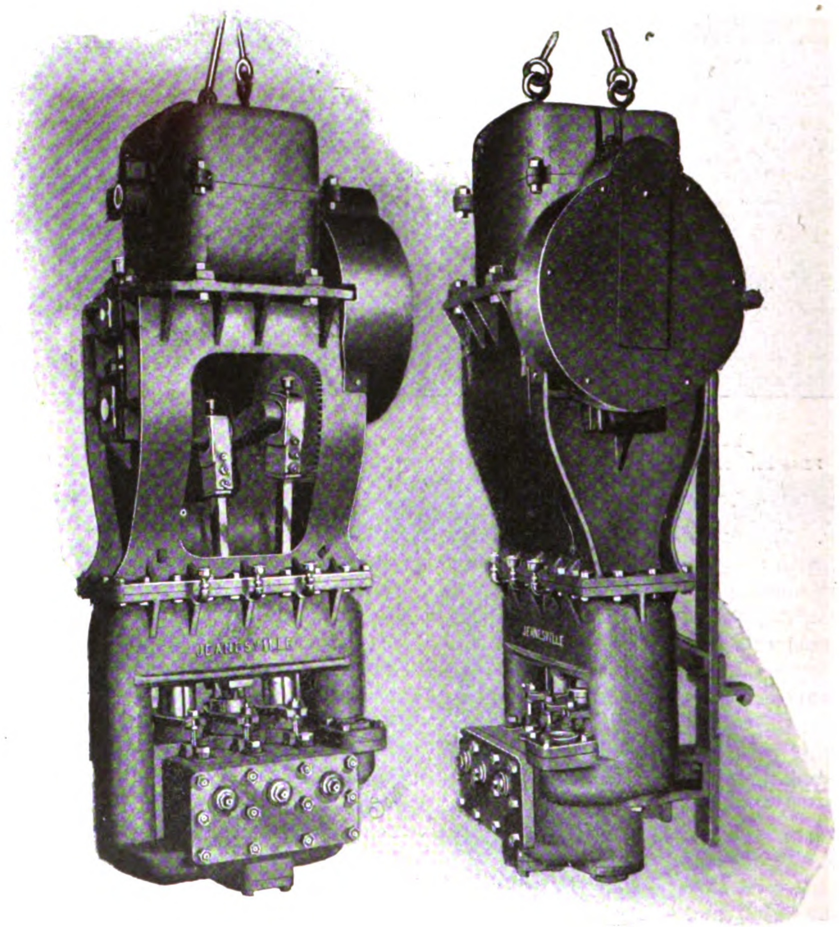
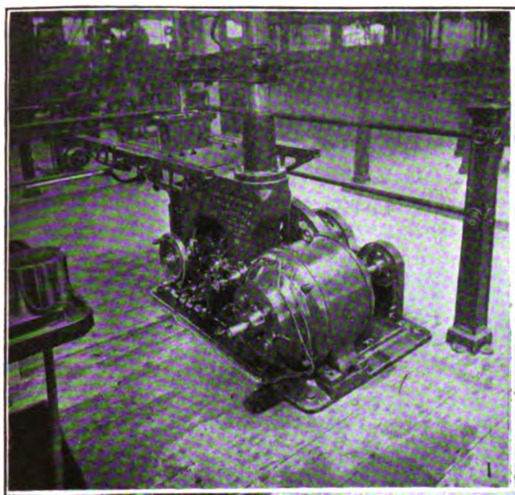


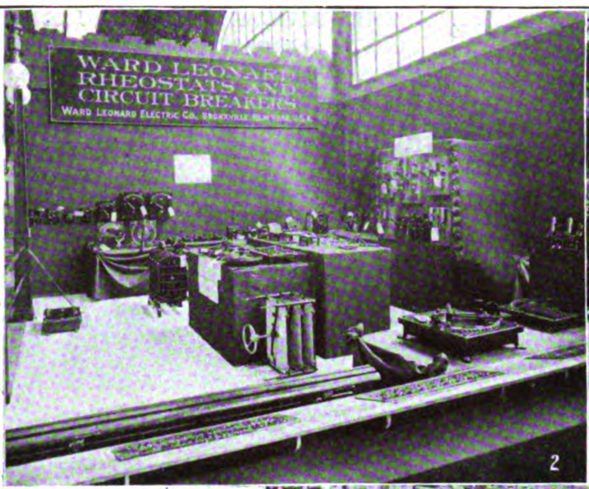
FIG. 16.—JEANESVILLE ELECTRICALLY DRIVEN SINKING PUMP FOR MINING SERVICE.

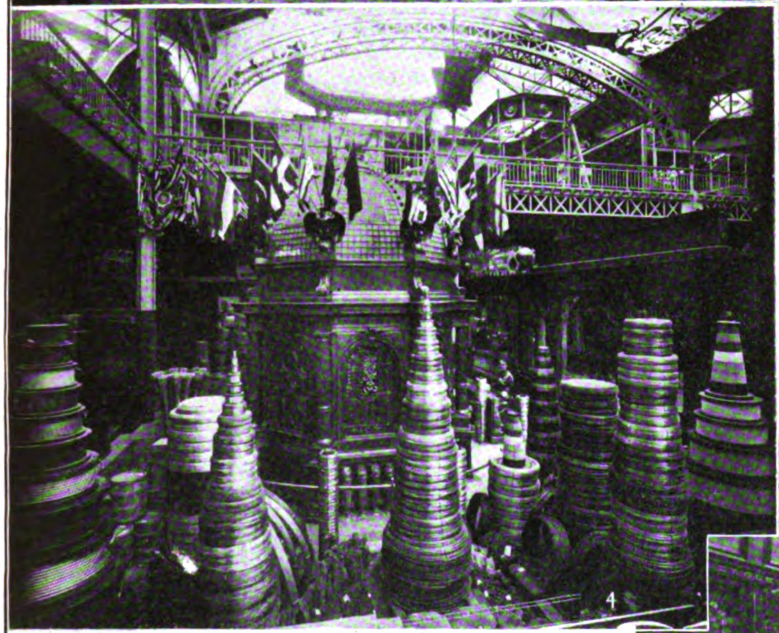
AMONG THE EXHIBITORS AT THE PARIS EXPOSITION.

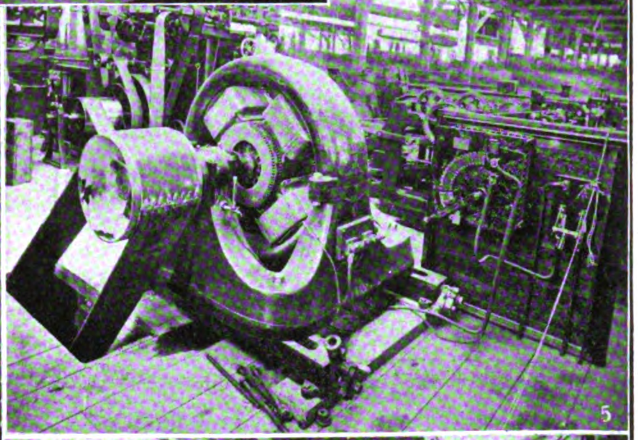
Next to France, the United States has the largest representation at the Paris Exposition, and of its 7000 exhibitors so large a proportion are electrical and mechanical as to make the department of Machinery and Electricity under Director F. E. Drake foremost in interest and importance. It is well known that the influx of American exhibits in Groups 4 and 5 was so great as to require the erection of a special American machinery hall at the Vincennes Annex for their reception; but it is not realized that kindred exhibits also fill up a large space in Electricity Building, occupying large areas in the Metallurgical, Textile and Transportation Buildings, and are again strikingly in evidence in a special United States Publishers' Building and in the Department of Liberal Arts, Agriculture, Sanitary Engineering and Navigation. In fact, when the numerous European reproductions of American apparatus are taken into account it is not saying too much to describe the influence of American mechanical skill and genius at the Exposition as all-pervasive.

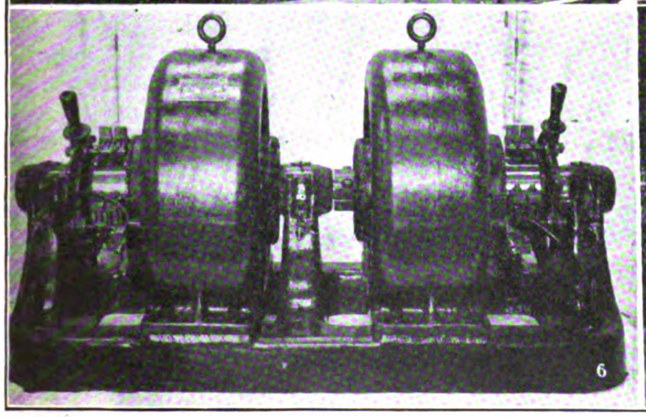
In earlier numbers of the American Electrician this year, we have devoted considerable space to the technical features of the great service plant of the Exposition for steam power, lighting, etc., and, as the present issue shows, we are

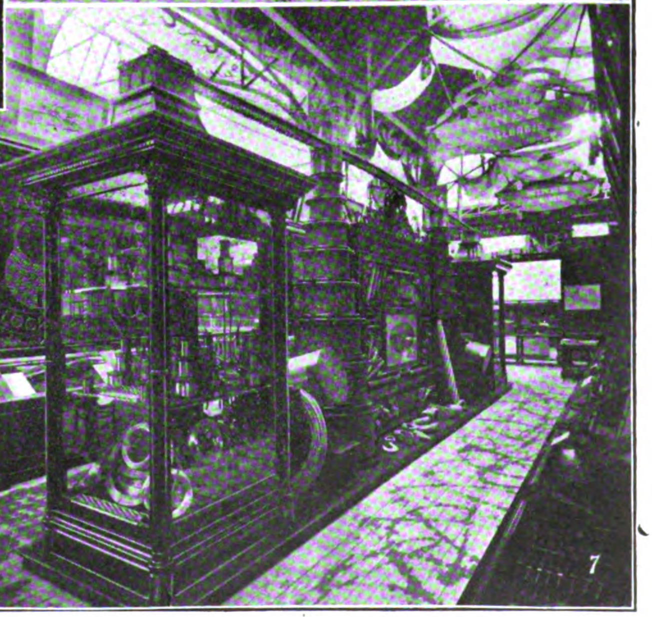












1—BULLOCK MOTOR DRIVING A KEYSEATER. 2—WARD LEONARD EXHIBIT. 3—HELIOS-UPTON EXHIBIT. 4—AMERICAN STEEL & WIRE CO.'S EXHIBIT. 5—60-H.P. TRIUMPH MOTOR. 6—CROCKER-WHEELER MOTOR DYNAMO. 7—ONE OF THE ROEBLING EXHIBITS.

making in each number a selection of other special topics for individual treatment. We now append also some running notes of the principal exhibits of interest to our readers, with a few typical illustrations. In view of the fact that out of 1053 entries in the electrical classes the United States has 385—to say nothing of proportionate figures in the mechanical and steam classes—it will be understood that only a rapid review of this general nature is possible.

THE LECLANCHE BATTERY COMPANY, New York, shows a line of its primary batteries.

THE EASTERN ELECTRIC CABLE COMPANY, Boston, has an exhibit of its wires and cables.

M. I. VOUGHT & CO., La Crosse, Wis., exhibit in actual use their ball drops for lamp suspension.

THE BELKNAP MOTOR COMPANY, Portland, Me., exhibited one of its well-known automatic voltage regulators.

THE NEW PROCESS RAWHIDE COMPANY, Syracuse, N. Y., shows some of its pinions in one of the collective cases.

THE MANHATTAN ELECTRICAL SUPPLY COMPANY, New York, shows its well-known "Mesco" batteries.

THE FEDERAL BATTERY COMPANY, New York, has a display of its batteries which has attracted much favorable attention.

THE STROMBERG-CARLSON TELEPHONE MANUFACTURING COMPANY, Chicago, exhibits one of its complete telephone sets.

THE ELECTRIC GAS LIGHTING COMPANY, Boston, exhibits a number of its well-known "Samson" batteries and other specialties.

THE ELECTRIC MOTOR & EQUIPMENT COMPANY, Newark, N. J., exhibits one of its Deshler-McAllister portable photometers.

THE AMERICAN ELECTRICAL HEATER COMPANY, Detroit, has on exhibition a line of its soldering irons, heating apparatus, etc.

THE NEW EXCELSIOR DRY BATTERY COMPANY, New York, interests many visitors in the various types of its dry batteries on exhibition.

THE MICA INSULATOR COMPANY, New York, shows samples of its mica and micanite in one of the cases, and has been awarded a gold medal by the Exposition authorities.

THE UNITED ELECTRIC HEATING COMPANY, Detroit, has its electric heating apparatus, soldering irons, etc., exhibited by the Compagnie Generale Electrique de Nancy.

THE VAN WAGONER & WILLIAMS HARDWARE COMPANY, Cleveland, Ohio, showed an assortment of its special iron and steel drop forgings, and copper commutator segments.

THE FARR TELEPHONE & CONSTRUCTION SUPPLY COMPANY, Chicago, makes a very effective display of its high-grade exchange apparatus, with long-distance transmitter and receiver.

THE COMMERCIAL ELECTRIC COMPANY, Indianapolis, Ind., has one of its 15-h.p. motors operating the system of the Batcheller Pneumatic Tube Company for carrying heavy packages and mail matter.

THE NATIONAL CARBON COMPANY, Cleveland, has a display on two large boards filled to their utmost capacity with innumerable carbon products for lamps, batteries, telephones, brushes, furnaces, etc.

THE WARREN ELECTRIC & SPECIALTY COMPANY, Warren, Ohio, is believed to be the only actual exhibitor of fan motors, though other manufacturers have furnished fan motors to the Exposition.

THE BALL ENGINE COMPANY, Erie, Pa., who furnished the 350-h.p. engine for the electric motive power for the special machinery exhibit of the United States at the Paris Exposition, has been awarded a gold medal by the Exposition authorities.

FELTEN & GUILLEAUME, Mulheim-on-Rhine, Germany, have on exhibition samples of their copper and steel wires in great variety from a great steel cable with a breaking strength of 2,400,000 pounds down to the smallest sizes of lamp cord.

THE PELTON WATER WHEEL COMPANY, San Francisco, Cal., through its Paris agents, Sloan & Company, has on exhibition one of its standard-size water motors; also a water wheel direct connected to an air compressor of the Rand Drill Company.

CROUSE-HINDS ELECTRIC COMPANY, Syracuse, N. Y., has its main exhibit in the United States Pavilion and the United States section of the Palace of Diversified Industries, for which it supplied all the panel boards, distribution boards and knife switches.

HELIOS-UPTON COMPANY, Philadelphia, show in their space near the collective exhibits in the gallery of the Electricity Building an attractive display of their well-known Helios and Midget arc lamps, with inner and outer globes, fixtures, brackets, etc.

THE NEW YORK & OHIO COMPANY, Warren, Ohio, has furnished many special lamps for the National Pavilion and the United States Commission. In addition the company also has in the collective exhibit in the Electricity Building some of its lamps and one of its transformers.

THE WARD LEONARD ELECTRIC COMPANY, Bronxville, New York, has a large space in the gallery of the Electricity Buildings where it shows a line of its well-known resistances, rheostats, dimmers, etc. This company has recently been informed that it has been awarded a gold medal for the excellence of its apparatus.

HART & HEGEMAN MANUFACTURING COMPANY, Hartford, Conn., has on exhibition in the gallery of the Electricity Building a neat display sample board of its switches. This exhibit, together with that of the Helios-Upton Company, is in charge of Mr. Rosenberg of H. H. Salmony, the London agent for both these companies.

THE C. J. TOERRING COMPANY, Philadelphia, furnished the Exposition Company with forty of its well-known enclosed arc lamps, which are suspended from the lofty posts in the gallery of the Electricity Building, furnishing ample and steady illumination and presenting a graceful and effective appearance. The company's lamps have been awarded a gold medal by the Exposition authorities.

THE UNITED STATES CARBON COMPANY, Cleveland, Ohio, shows a complete line of its carbons used as anodes in electrolysis, die made and very dense. They range from ¼x1x4 ins. to 3½x8x24 ins. The company also exhibits its standard size carbons for electro-metallurgical work, ranging from ⅜ in. and 18 ins. long for aluminum work, up to 9 ins. diameter by 30 ins. long, used in the production of carbide. Their exhibits include a full line of arc-light carbons, solid and cored.

THE CROCKER-WHEELER COMPANY, Ampere, N. J., has a motor-generator set, installed by the United States authorities for use in transforming the voltage supplied to the Publishers' Building from 500 volts to 230 volts. The current thus obtained is used in operating a number of motors driving all kinds of machinery employed in the printing and publishing trades. In addition to this machine there are a number of Crocker-Wheeler motors throughout the building operating printing-press equipments.

JOHN A ROEBLING'S SONS COMPANY, of Trenton, N. J., has two exhibits at the Exposition. One of these, of electrical wires and cables, is to be found in Electricity Building, and comprises all of the Roebling manufactures in trolley, weatherproof, magnet, electric light and power, and telephony, as to conductors; while there is also a fine display of power and telephone cables and lead-encased cables of all kinds. A section of electric railway track is provided to exemplify the method of connecting up underground cables with the slot trolley system of circuits. The company has another fine display in the Mining and Metallurgical Building, chiefly devoted to wire rope and wire. There is a number of reels of wire roping, with two cabinets of samples of wire and rope used for a great variety of purposes. These all attract attention, but the chief item is a superb model of the Brooklyn Bridge worked out in fine detail, and standing above a center board on which are displayed various pieces of rope and fittings. Mr. William S. Rogers is in charge of both exhibits.

THE BULLOCK ELECTRIC MANUFACTURING COMPANY, Cincinnati, O., has one of its 30-h.p. motors operating a large Goss straight-line press, which is

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A MODERN STREET LIGHTING PLANT.

THE MUNICIPAL ARC LIGHT PLANT AT GRAND RAPIDS, MICH.

BY GEORGE A. DAMON.

Grand Rapids is a city of about 100,000 people and is the second city in point of size in the state of Michigan. It is the center of the furniture industry, and is situated in the midst of a famous fruit belt. Its street lighting plant was installed at a cost of $180,000 and has been in operation since January 1, 1900. It furnishes current to 500 arc lamps, or one to every 200 inhabitants. These lamps are connected by 84 miles of overhead weatherproof wire and four miles of underground lead-covered cable, divided into eight circuits. The city contains 283 miles of streets and covers an area of 17½ square miles, so that there is an average of 28 lamps per square mile of territory served.

The lamps are of the enclosed type, using 6.6 amperes, direct-current, at a pressure of 70 volts per lamp, and were furnished by the Adams-Bagnall Electric Company, of Cleveland, Ohio. The light distribution is fully as satisfactory as that given by the open arcs which were displaced. Three methods of lamp suspension have been adopted. There are forty towers which were bought from the company formerly having the lighting contract, and which are equipped with four lamps each. The circuit to the tower lamps passes first through a double-pole switch, and thence up two of the corners of the triangular tower frame. The wires are supported only at the top by insulators, while a weight is attached to the bottom to keep the wire taut and at the same time allow for contraction and expansion. The wires are held away from the tower frame by round porcelain insulators through which it passes, but which do not support it.

Forty lamps are suspended upon ornamental poles in the down-town underground district. These poles consist of an ornamental cast iron base supporting a 15-ft. 7-in. round wooden section made up of four pieces of 4 ins. by 4 ins., in such a way as to leave a hole up the

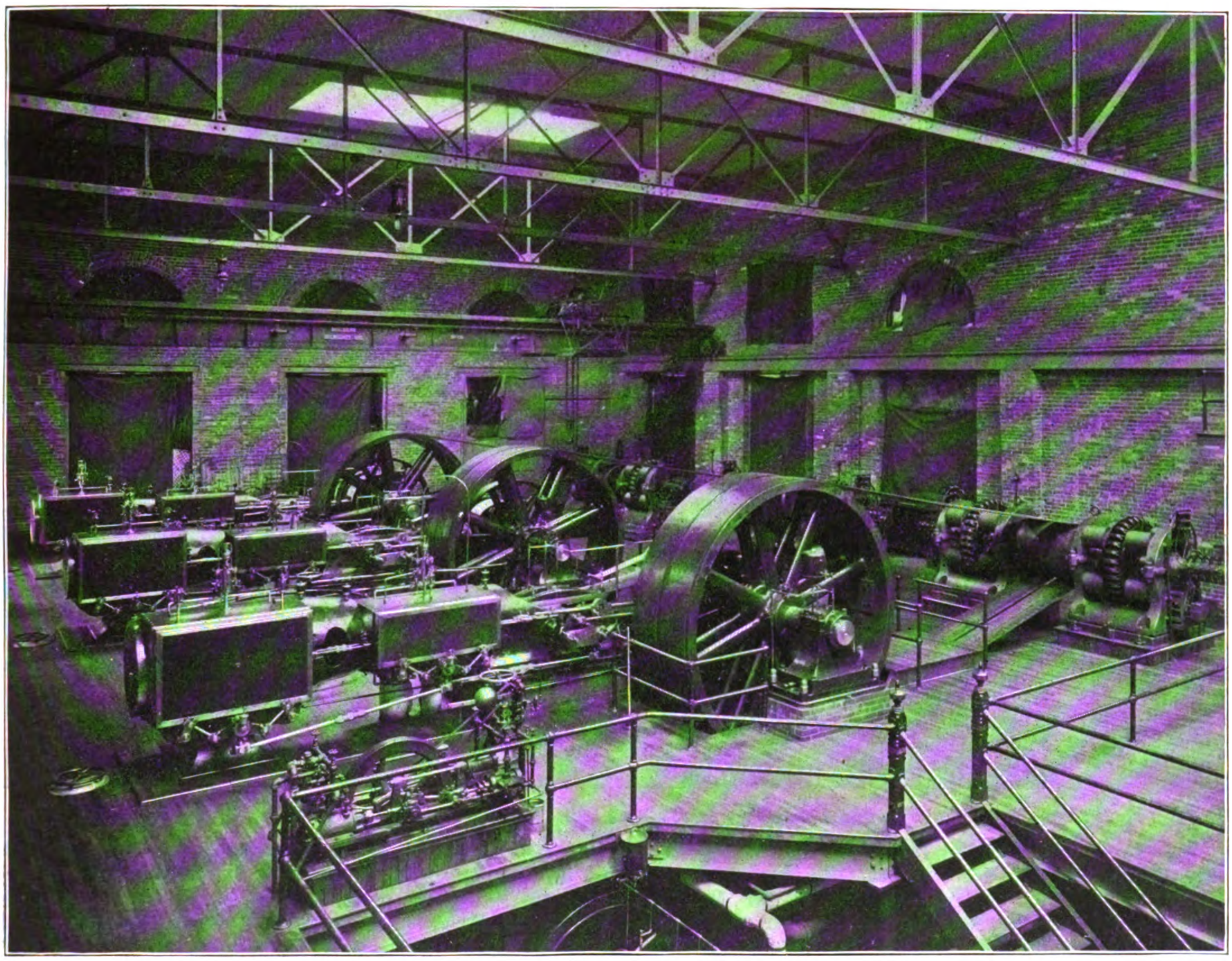


FIG. 1.—VIEW OF GENERATING ROOM, WITH REFERENCE PARTICULARLY TO THE ENGINES.

center of the pole. Each pole is provided with a cut-out switch mounted on a hard rubber base and contained in a porcelain lined iron box. The lead cable from the underground conduits is brought to the brass unions in the bottom of this switch and a plumber's wiped joint is made. The connection of the navy core wire passing up to the lamp from the switch is waterproofed with P. & B. compound and a rubber gasket is inserted when the cap is screwed on the switch-box.

The other 260 lamps are hung by the usual cross-suspension method over the center of the street. Upon streets containing trolley wires the lamps are equipped with the Fletcher travelling pulleys and in all cases automatic suspension pulleys made by the Fletcher Manufacturing Company, of Dayton, Ohio, are used.

The lead cable in the underground district is carried at street crossings in conduit, which consists of 2-in. wrought iron pipe coated inside and outside with asphaltum. Between street corners the wires run, as a rule, in the area-ways beneath the sidewalks. In these basements the lead-covered cable is suspended by means of galvanized iron clips, located at intervals of 6 ins.

The pole line conductor consists of triple-braided weather-proof wire carried on Locke triple-petticoat glass insulators. Every loop over two blocks in length is provided with a cut-off switch of the pattern used on the towers.

The circuits are protected by 64 lightning arresters made by the Garton-Daniels Company, Keokuk, Ia.; 32 of these (four on each circuit) are connected to the lines just before they leave the power house. On account of the high voltage it is necessary to put two arresters in series between the line and the ground. The ground connections consist of copper plates 1 ft. square, buried in the earth below the water line.

The general arrangement of the power plant and its equipment is shown in Fig. 3. Only one-half of the machinery indicated upon the general plan has been installed up to the present time, abundant provision having been made for future extension. The plant now has a dynamo capacity sufficient to furnish current to 900 arc lamps, which is divided into six electrical units. The six dynamos are belted to three engines. The engine and boiler rooms are on the same level and a basement is provided for the piping and auxiliaries. There are four 150-h.p. Cahall horizontal water-tube boilers, set in two batteries, and built by the Aultman & Taylor Machinery Company, Mansfield, O. Each boiler has 1588 sq. ft. of heating surface and is equipped with a Hawley downdraft furnace containing 27½ sq. ft. of water grate surface. The coal is delivered to the plant by wagons and stored in bins directly in front of the boilers. The boiler-room is provided with coal scales and all coal burned is weighed and a record kept of the amount used on each day's run. A railroad siding will be installed eventually and the coal cartage expense will thus be eliminated.

Back of the boilers and next to the dividing wall between the engine and boiler rooms is a Green fuel economizer. The main gas flue is connected at one end directly to the stack and at the other to the economizer passage, and dampers have been provided so that the economizer can readily be cut out of service. There are in place at present 168 economizer tubes each 9 ft. long and arranged in 28 rows of six each, resulting in a water-heating surface of 2016 sq. ft. The location of the economizer brings the blow-off header in an open passage-way back of the boilers and allows easy access to the soot chamber below for cleaning purposes. The scrapers are belt-driven by a small engine on the boiler-room floor. Directly in the flue passage leading to the

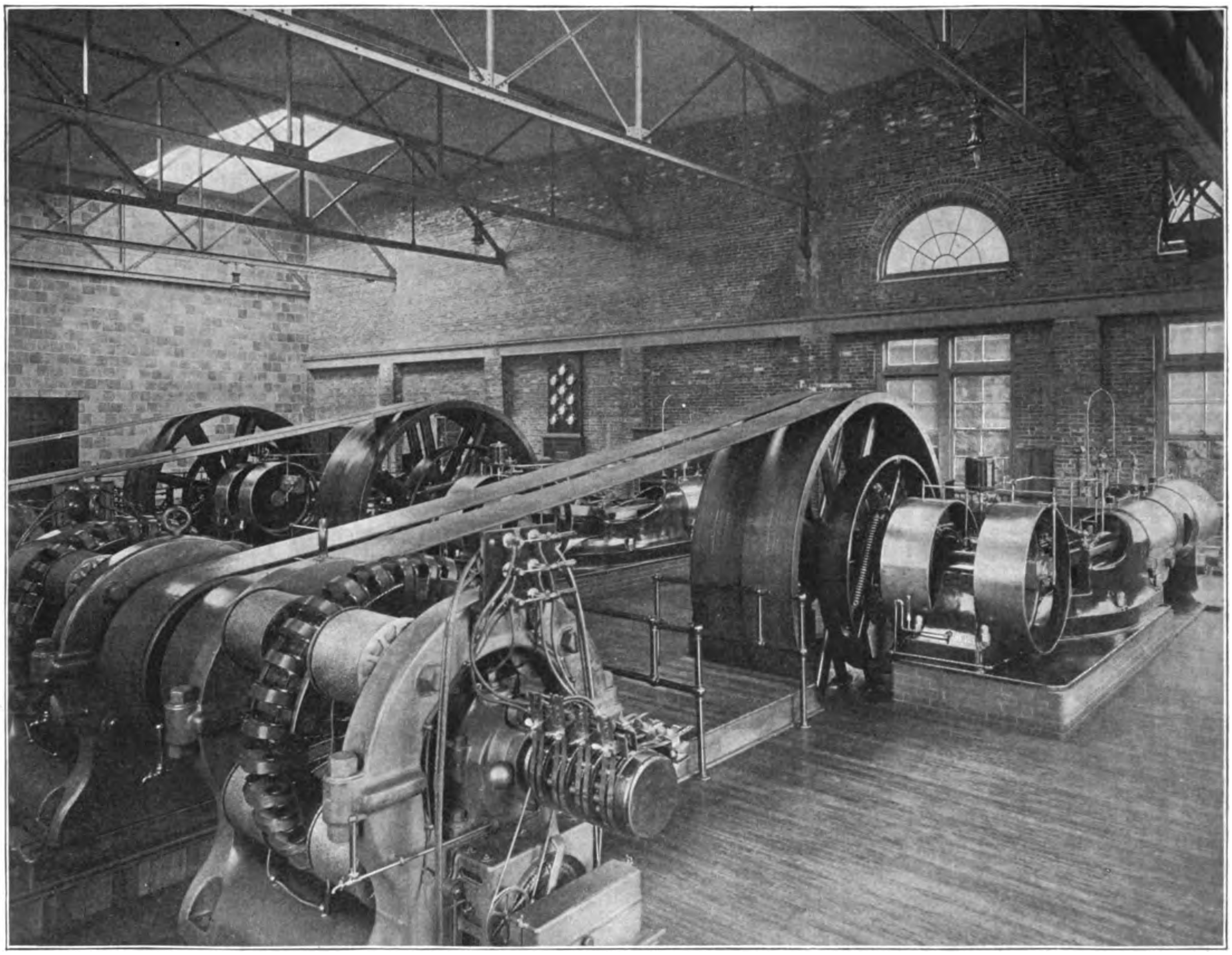


FIG. 2.—VIEW OF GENERATING ROOM FROM THE DYNAMO SIDE.

stack is a swinging damper controlled by a Locke damper regulator conveniently placed within reach of the boiler-room floor.

The stack is outside of the building, on a separate stone foundation which extends 18 ft. above the boiler floor level and is 15 ft. square at the top. The stack is of steel, lined with brick to the top. It has a clear bore of 66 ins. diameter, and extends 165 ft. above the grates. The steel plates vary in thickness from 3/16 in. with ½-in. rivets at the top to ⅜ in. with ¾-in. rivets in the bottom section, a uniform pitch of 3 ins. being used for the rivets throughout. The bell is 13 ft. in diameter at the base plate and the stack gracefully tapers to the ornamental top. The lining consists of 20 ft. of 13-in. brick, 30 ft. of 9-in. brick, 30 ft. of 6-in., 30 ft. of 4½-in., and a final 35-ft. course of 3-in. brick.

The engine-room is spanned by a hand crane having a capacity of 12,500 lbs. The engines and generators are set on massive brick foundations extending below the basement floor level. The dynamo foundations are capped by heavy timber framework bolted solidly to the brick work, and the generator frames are insulated from the holding-down bolts by hard rubber washers.

The engines are of the horizontal tandem-compound four-valve type, built by the Russell Engine Company, Massillon, Ohio. The cylinders are 13 ins. and 27 ins. in diameter, respectively, the stroke is 24 ins. and the engines run at 135 r.p.m. They are rated at 300 horsepower each. The flywheels are provided **each with a double set of arms and a pulley face 40 ins. wide, turned with a double crown to accommodate two dynamo belts.**

Two generators are belted to each engine by means of double belts, each 16 ins. wide. The dynamos are of the latest Brush multi-circuit type rated at 10,500 volts and 6.5 amperes when running at 500 r.p.m. Each dynamo furnishes current to two separate circuits, so that the line voltage leaving the switchboard may be kept down to one-half the maximum voltage of the machine, although it is possible to operate the full lamp capacity of the dynamo upon either circuit. At the machine the two circuits are combined so that the current is controlled by one regulator. Although rated at 150 70-volt

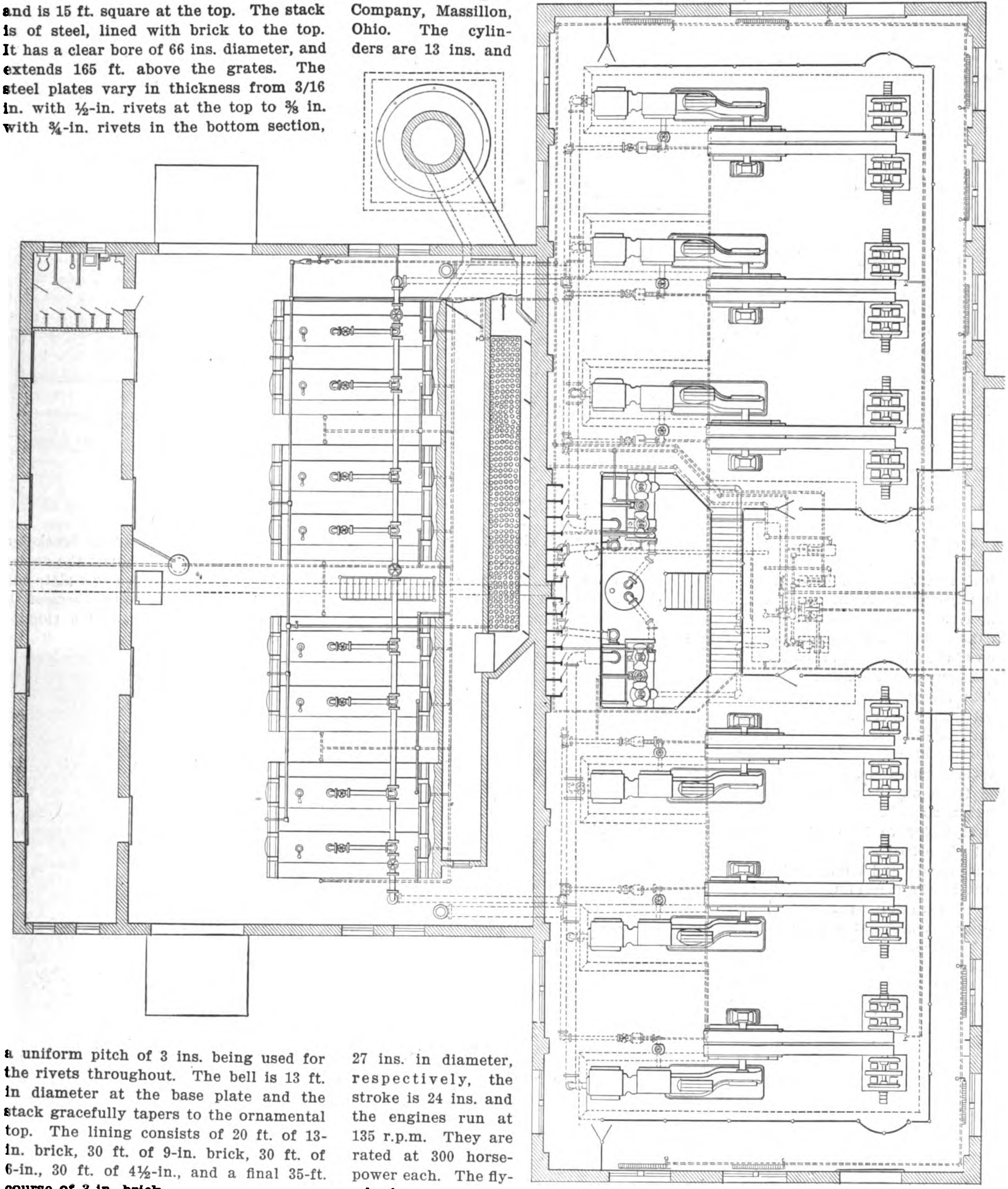


FIG. 8.—PLAN OF THE ENTIRE POWER HOUSE; GRAND RAPIDS MUNICIPAL PLANT.

lamps, the range of the regulation is sufficient for an output of 175 lamps.

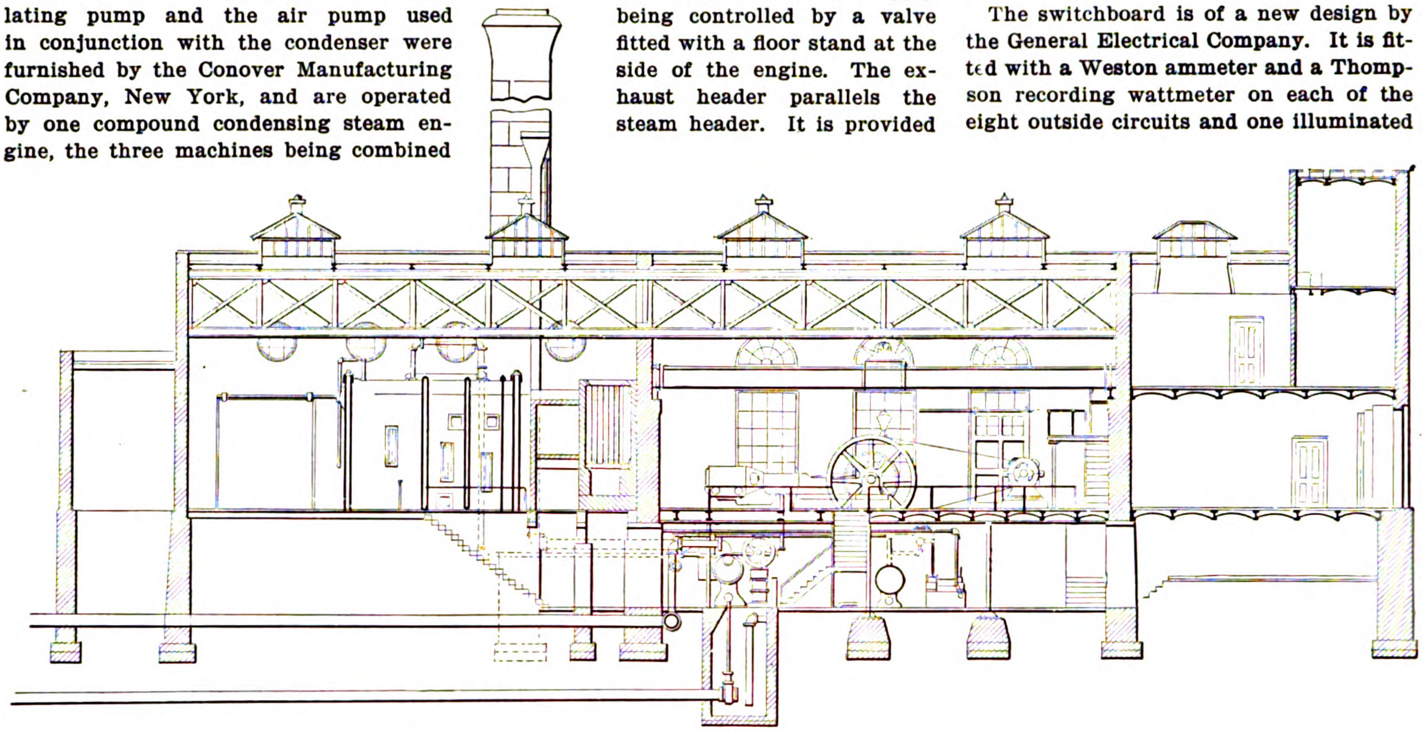


FIG. 4.—SECTIONAL ELEVATION OF THE GRAND RAPIDS POWER HOUSE.

One Wainwright surface condenser of 800-h.p. capacity takes care of the exhaust from all three engines. The circulating pump and the air pump used in conjunction with the condenser were furnished by the Conover Manufacturing Company, New York, and are operated by one compound condensing steam engine, the three machines being combined in a single structure. The circulating water is taken from an injection well which receives its supply by gravity from the adjacent river, through a 16-in. pipe. The condenser is located in the basement in the middle of the plant, near the bottom of the stairway and within clear view of the engine-room floor.

The air pump discharges from its hot well into a sheet iron surge tank 3 ft. 6 ins. in diameter and 18 ft. long. This reservoir also receives the exhaust from the feed pumps and the discharge from the traps on the drainage and heating system, so that it provides a source of warm water to be used for the boiler feed. The feed pumps are simple duplex steam pumps and are located in the basement at the side of the surge tank. In the pipe leading from the pumps to the boilers a Worthington hot water test meter has been installed on a brick pedestal where its dial can easily be read. This meter is used to determine the total amount of water evaporated each day.

The heating of the engine room, store room and offices is accomplished by direct radiators, using the exhaust steam from the pumps, except during severe weather, when live steam is introduced into the system through an automatic pressure-reducing valve.

The piping is laid out with considerable care and its lack of vibration and freedom from leaks are evidences of the careful study given it. An 8-in. steam header supported on saddles fastened to the tops of the boiler drums takes steam from 5-in. bends attached to the boiler outlets. This header extends down the side of the boilers into an alley-way leading into the engine-room basement, and thence into the top of the main steam header running along near the ends of the engine foundations. Each engine takes steam from the top of the header, the supply being controlled by a valve fitted with a floor stand at the side of the engine. The exhaust header parallels the steam header. It is provided with a spiral riveted atmospheric exhaust controlled by an automatic back-pressure valve. All main valves are of the outside screw and yoke pattern and Rainbow packing is used at all joints.

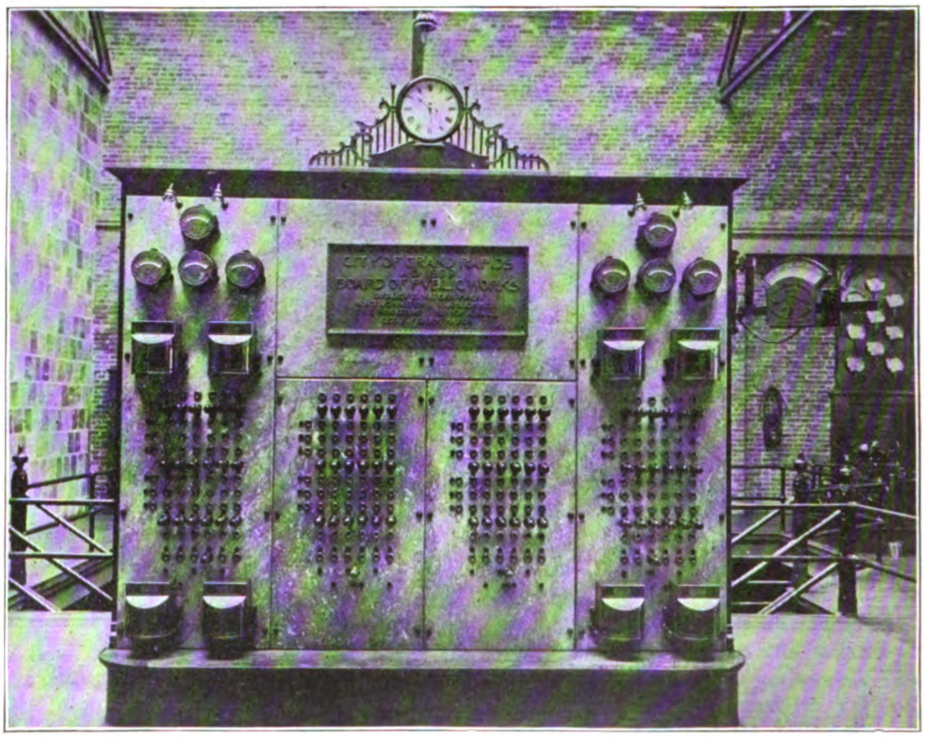


FIG. 5.—THE SWITCHBOARD.

A Bundy oil separator is inserted in the 14-in. exhaust pipe leading to the condenser.

A small Clayton air compressor is used to charge an air reservoir connected with the automatic oiling system on the engines, from which a drainage system takes the oil back to the filter in the basement to be purified and again used. Air is also taken from this reservoir for cleaning the dynamos.

The switchboard is of a new design by the General Electrical Company. It is fitted with a Weston ammeter and a Thompson recording wattmeter on each of the eight outside circuits and one illuminated dial voltmeter on a swinging bracket at the right of the board. Upon the central panel is an ornate bronze name-plate containing the names of the members of the Board of Public Works, and a clock is supported above the board by an ornamental bronze bracket. The board itself is mounted on a highly polished oak frame built in the form of a cabinet so as to inclose the back connections.

The building itself is a handsome structure built of brick and very solidly constructed. The engine and boiler rooms are spanned with steel trusses and the roof is provided with combined skylights and ventilators. The front extension contains an electrician's office, an engineer's office and a supply store upon the first floor with a draughting room, two sleeping rooms and a bath room on the second floor. A locker room fitted with closets, wash basins and two shower baths adjoins the boiler room for the accommodation of the engineer and boiler attendants.

The contract for the power plant equipment contained an economy clause calling for the development of a kilowatt-hour at the generator terminals with a consumption of 28 lbs. of commercially dry steam, and a penalty clause requiring a forfeiture of $1000 for each pound required above the guarantee. These conditions imparted considerable interest to the final test of the plant, which was made by Bion J. Arnold, of Chicago. Extracts from the report of this test are appended, and curves are shown by Figs. 6 and 7. The test load was obtained by putting six circuits on two dynamos, resulting in an efficient load for one engine. But one boiler, one pump and the condenser were operated.

Three water barrels were rigged with scales in the pump room, all arranged in discharge into a common boiler-feed reservoir. Two of these barrels were used to weigh the water discharged by the air pump from the surface condenser, and the other barrel caught the water discharged from the trap upon the steam pipe drainage system, and was also used to weigh the cold water introduced from the city mains into the system.

The test was divided into two periods of five hours each. During the first period the condenser was run condensing, and during the last five hours it was run exhausting, as did the feed pumps during the entire period, into the heating system. The last half of the test, therefore, showed exactly the water consumption of the engines, as the water was weighed directly from the condenser. The hot well was not used at all during the test run. The water meter showed the total of three barrels, which was the amount of water pumped into the boilers.

A start was made on the boiler by the "alternate" method. Observations were taken at regular intervals of the temperature of the outside air, of the boiler room, of the water at the meter, and after pass-

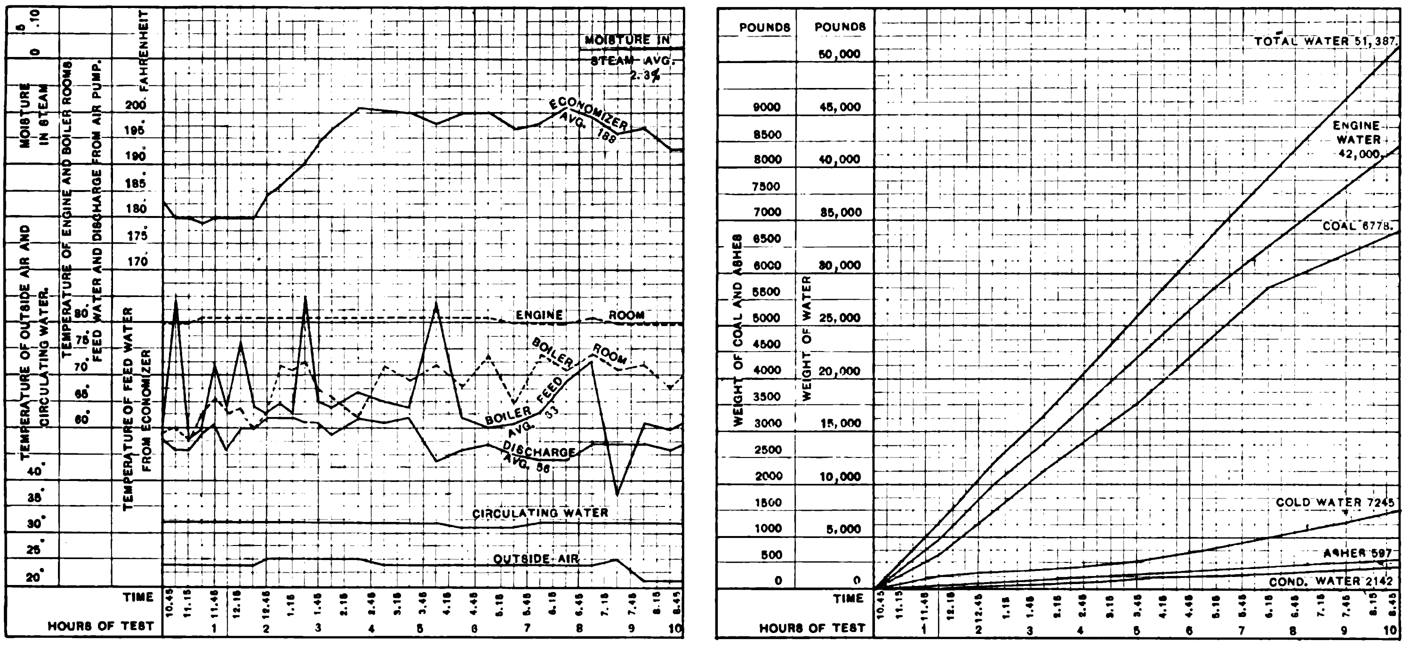


FIG. 6.—TWO OF THE TEST LOGS.

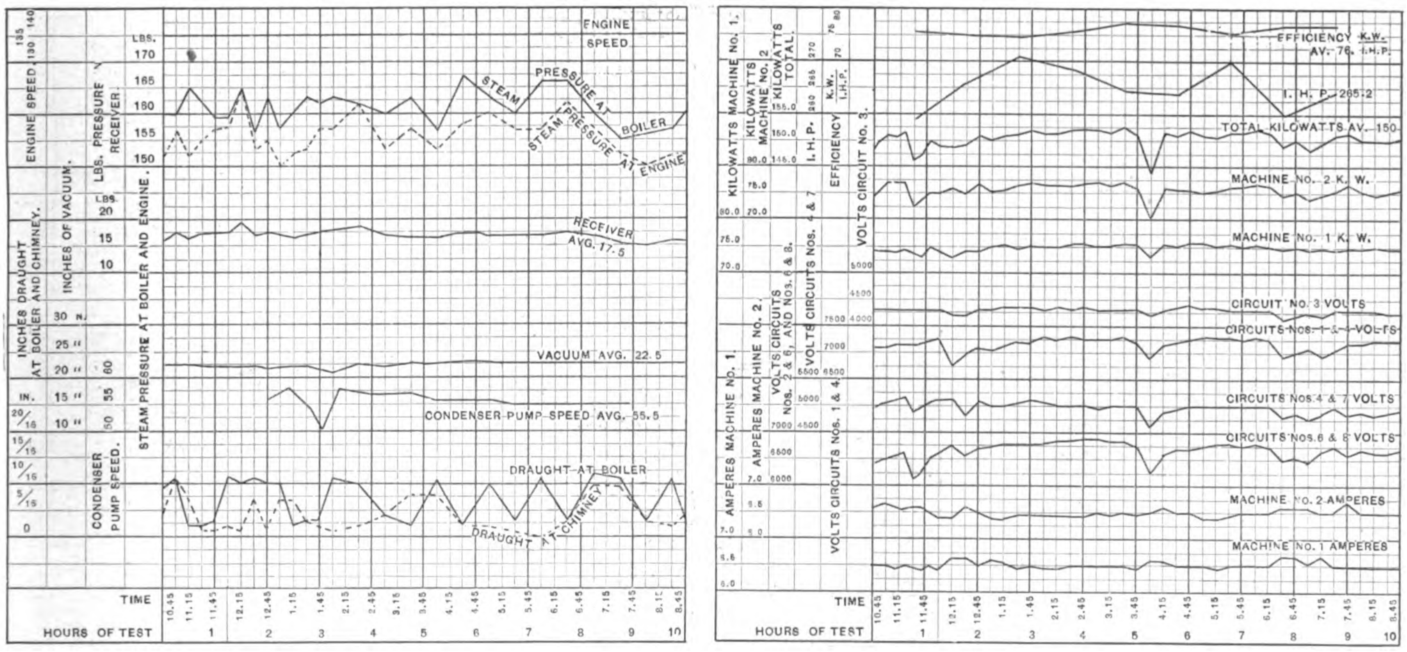


FIG. 7.—TWO OF THE TEST LOGS.

ing the economizer, and of the flue gases leaving the boiler breeching and at the stack; the pressure of the steam at the boiler, at the engine and in the receiver and the vacuum in inches; the speed of the dynamos, of the engine, and of the condenser pumps; the volts of each circuit and the amperes from each machine. The indicated horse-power of the engines was taken frequently, and the moisture in the steam determined by a Barrus calorimeter.

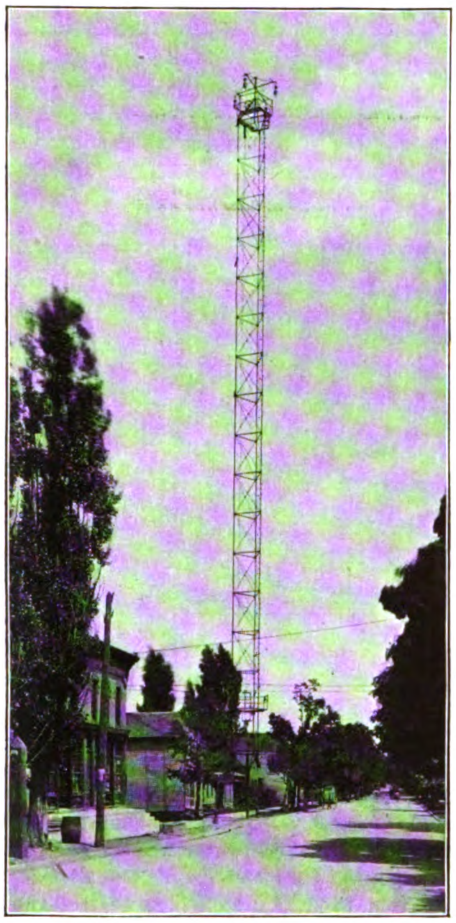


FIG. 8.—ONE OF THE TOWERS.

The following precautions were taken to insure accuracy and satisfaction with the results:

All steam and water lines were tight, and two condensation and leakage tests with the system standing idle were made preliminary to the final run. The connection from the city mains direct to the boiler was broken and plugged; the blow-off system was disconnected from the sewer and capped; the live steam connections to the heating system and to the jet pump on the sewage were opened to insure that any leakage of the valves would be detected. All scales were calibrated and found correct. A standard portable ammeter and voltmeter were used instead of the switchboard instrument. Of water, coal and electric output, two independent logs were kept. The water level in the boiler and the condition of the furnace fire were the same at the beginning and end of each test.

Everything worked very smoothly, and nothing happened to interfere with the accuracy of the test. All the observations are shown in the graphical logs, Fig. 6 and 7, which will obviate the necessity of reciting the actual figures in most cases. The following results will be of interest:

Kind of fuel	Hocking Valley nut coal
Ratio of water heating surface to grate surface	58 to 1
Percentage of ash and refuse in dry coal	10%
Dry coal burned per sq. ft. of grate surface per hour	21.4 lbs.
Percentage of rated horse-power developed by boiler	107%
Equivalent evaporation from end and at 212 deg. per pound of dry coal (not corrected for moisture)	9.36 lbs.
Average total kilowatts on both dynamos throughout test	150
Average indicated horse-power of engine	265.2
Average efficiency; indicated horse-power to output on switchboard	76%
Water per kilowatt-hour used by engine and condenser	29.46 lbs.
Average per cent. of moisture in steam at engine	2.3%
Average water per kilowatt-hour used by engine alone (not corrected for moisture)	26.64 lbs.
Indicated horse-power per kilowatt output	1.77
Pounds of water per I.H.P-hour consumed by engine alone (not corrected for moisture)	15
Pounds of steam per kilowatt allowed for condenser at ½ lb. per I.H.P	0.89
Total steam consumption per kilowatt hour to compare with contractor's guarantee of 28 lbs	27.53 lbs.
Condensation for entire test	2143 lbs.
Per cent. condensation of total water evaporated	4%
Water used by condenser when running condensing, per I.H.P.-hour of engine	1.58 lbs.
Water used by feed pump per I.H.P.-hour of engine	0.8 lbs
Total water pumped into boiler per kilowatt-hour	34.26 lbs.
Coal burned per kilowatt-hour (wet)	4.53 lbs.
Coal per I.H.P.-hour (wet)	2.55 lbs.
Kilowatts per lamp	0.43
I.H.P. per lamp	0.75
Coal per lamp-hour (wet)	1.94 lbs.
Percentage of economy gained by use of economizer (Formula, $100 \frac{H-T}{H-t}$)	10.7%

In the above formula T = temperature of boiler feed from economizer; t = temperature of boiler feed to economizer, and H = total heat units in steam at boiler pressure.

The poor vacuum is to be explained by the fact that there was a slight break in the exhaust system. The excessive consumption per i.h.p.-hour by the condenser pumps is due to operating an 800-h.p. condenser in connection with a 300-h.p. engine. All the other conditions were fairly constant and favorable to an economical showing.

The Board of Public Works, in their annual report, give the cost per lamp per year as $48.55, based upon the expense of operating during the first six months. Their future reports will be watched with much interest. Much credit is due to Mr. W. D. Ball and Mr. A. F. Nagle, who were the consulting engineers for the Board during the design and construction of the plant.

A WATER=POWER RAILWAY PLANT.

Power House of the Toledo & Maumee Valley Traction Company.

BY W. N. ZURFLUH.

One of the earliest interurban traction lines established in Ohio was that of the Toledo & Maumee Valley Traction Company. This road was built in 1894, and originally connected the city of Toledo with the towns of Maumee and Perrysburg, Ohio. A branch was later built to Bowling Green, and finally extended to Jerry City, 17 miles south of Perrysburg. The road was a financial success from the start, as the country through which it passes is one of the most picturesque and historical in the central states.

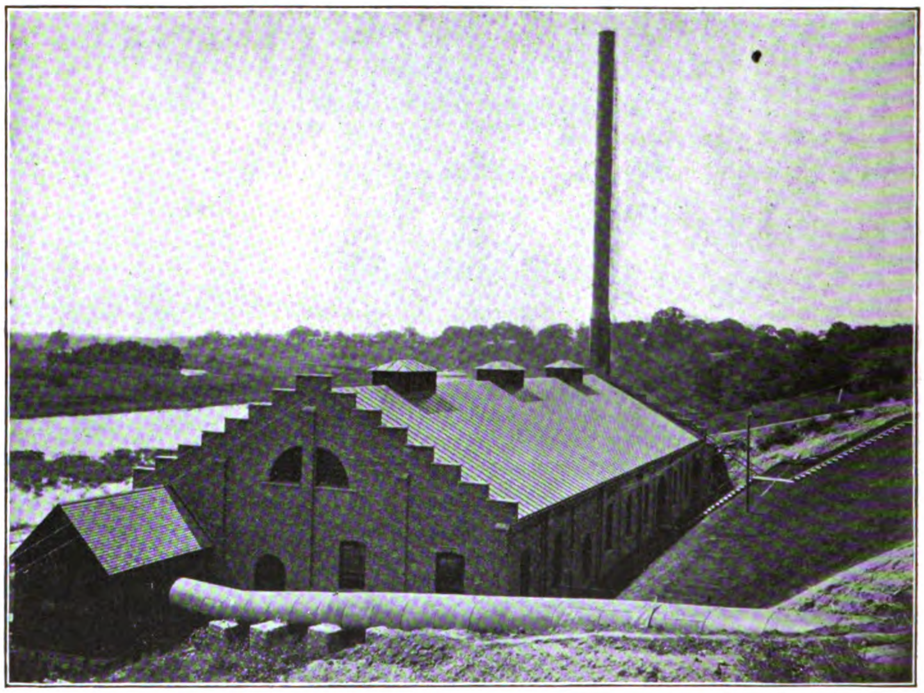
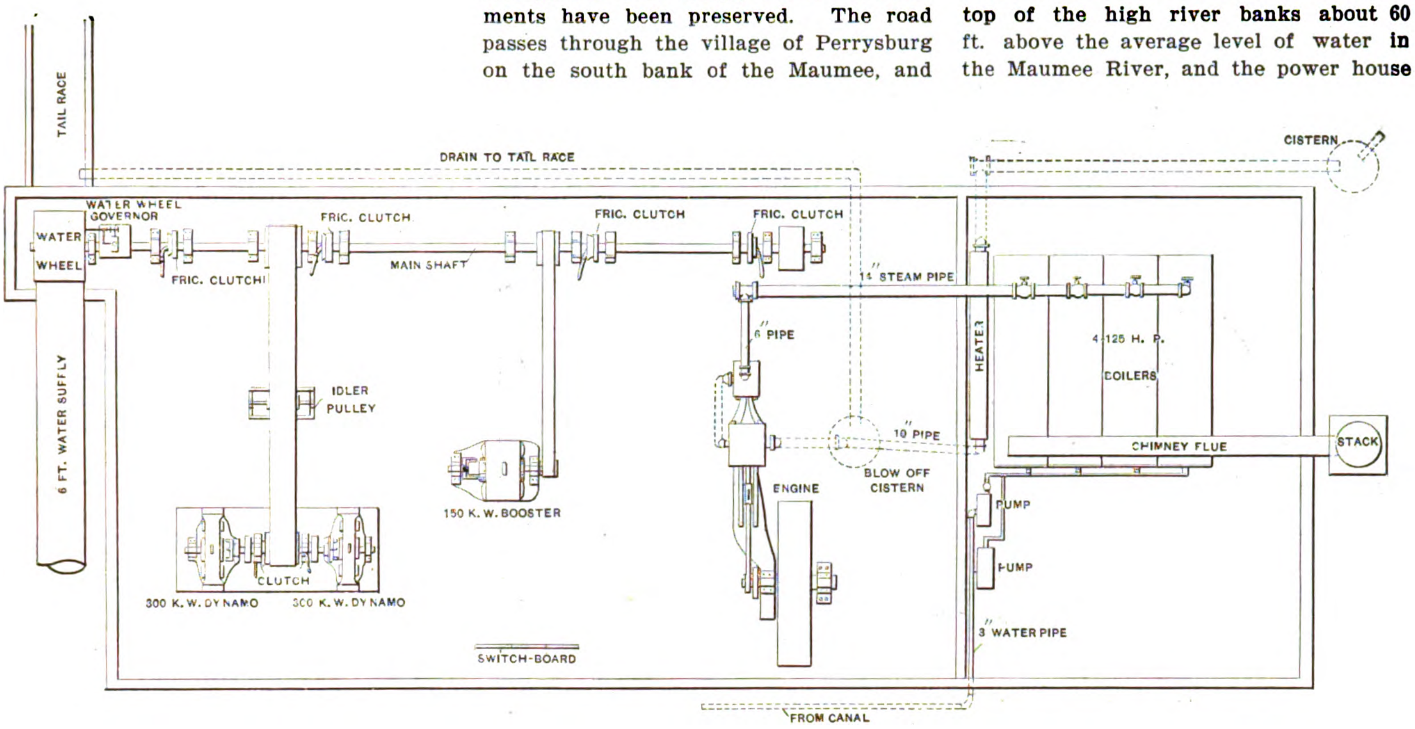


FIG. 1.—SHOWING APPROACH OF FLUME TO POWER HOUSE.

Leaving Toledo on the north side of the river, the Toledo Traction Company's track follows the winding river road to Maumee, where it crosses the Maumee River on a substantial four-truss steel bridge. At the village of Miami the track goes within stone's throw of the old British Fort Miami, the embankments of which may yet plainly be seen. From this point two miles to the west the road traverses the ground covered by the Indians after their defeat in the Battle of Fallen Timbers, in 1749. The battle-field proper is further west, about two miles, where may be seen the "Turkey Foot Rock," a monument erected to the memory of an Indian chief of that name.

After crossing the bridge the road follows a heavy fill in full view of the river, and passes Fort Meigs, whose embankments have been preserved. The road passes through the village of Perrysburg on the south bank of the Maumee, and continues along the river all the way to East Toledo, where again the tracks of the Toledo Traction Company are used to enter the city. The crossing is made to the north of the river over the public driveway bridge at Cherry street. The road is a so-called belt line.


TAIL RACE
DRAIN TO TAIL RACE
CISTERN
WATER WHEEL GOVERNOR
WATER WHEEL
FRIC. CLUTCH
FRIC. CLUTCH
FRIC. CLUTCH
FRIC. CLUTCH
MAIN SHAFT
14" STEAM PIPE
6" PIPE
IDLER PULLEY
4-125 H. P. BOILERS
HEATER
10" PIPE
BLOW OFF CISTERN
CHIMNEY FLUE
STACK
ENGINE
PUMP
PUMP
6 FT. WATER SUPPLY
150 K. W. BOOSTER
CLUTCH
300 K. W. DYNAMO
300 K. W. DYNAMO
SWITCH-BOARD
3" WATER PIPE
FROM CANAL

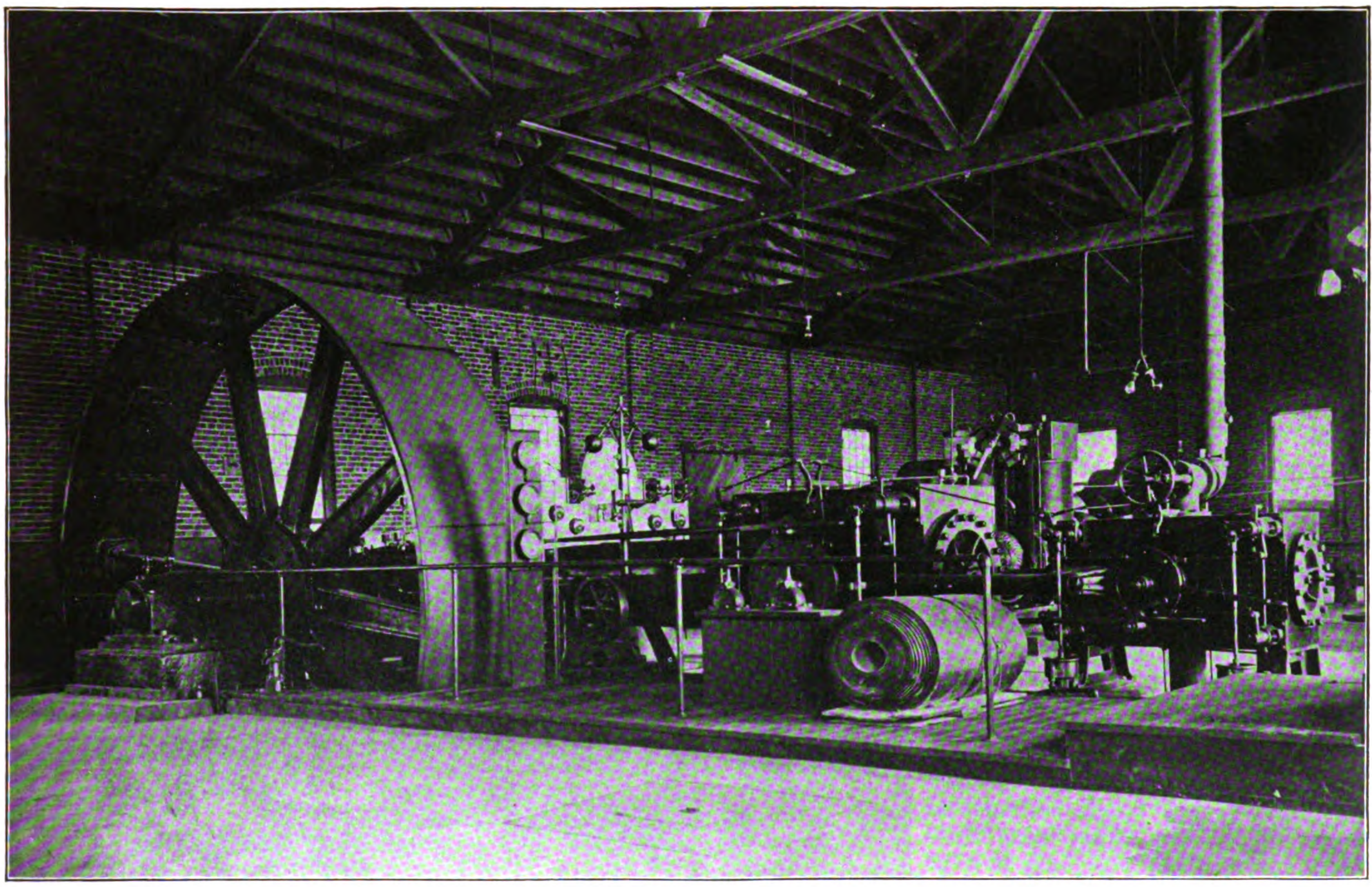


FIG. 3.—AUXILIARY ENGINE IN THE MAUMEE POWER HOUSE.

The most interesting feature of the road is its new power house at Maumee. The Wabash and Erie Canal runs along the top of the high river banks about 60 ft. above the average level of water in the Maumee River, and the power house has been located so as to utilize this power. A flume with an average width of 13 ft. was dug from the canal, which is but 250 ft. from the river bank, to a point about 90 ft. away, where it discharges into a steel pipe 6 ft. in diameter, which carries the water down to the power house on the river bank at the bottom of the declivity. The arrangement is shown in Fig. 1. The length of the steel flume is 170 ft.; it is built of ¼-in. steel plates.

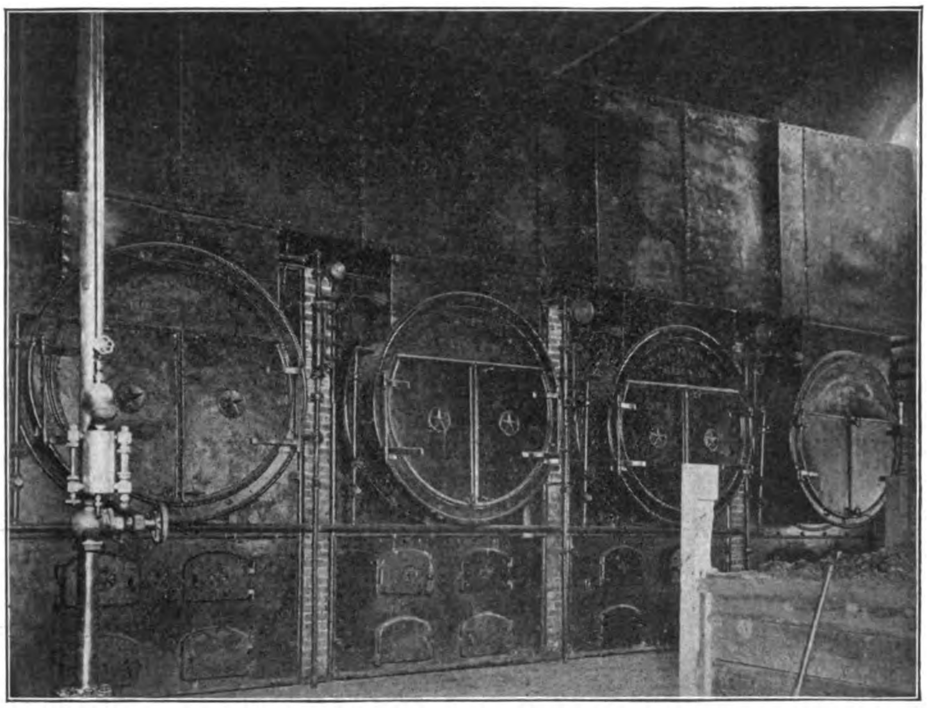


FIG. 4.—BOILERS OF AUXILIARY STEAM PLANT.

The power house is a brick structure 150 ft. long and 60 ft. wide, with an iron roof. The generating equipment consists of a 600-h.p. Leffel turbine and a 500-h.p. auxiliary steam plant for use in case of failure in the water supply or of any temporary extraordinary demand for power. The boiler room is at the western end of the building and is separated from the engine room by a solid brick wall. The water wheel is 40 ins. in diameter, made of bronze, and weighs 1950 lbs.; it is a horizontal wheel with a casing 6 ft. long parallel with the shaft and 8 ft. in diameter. The wheel sets 15 ft. above the tail race and discharges through two 3-ft. draft tubes which extend, of course, considerably below the low-water level of the tail race. The speed of the wheel is regulated by a Lombard water-wheel governor.

The steam plant comprises four 125-h.p. horizontal return-tubular boilers, built by the Shaw, Kendall & Co., of Toledo, Ohio, set in a single battery, and one 500-h.p. tandem-compound Hamilton-Corliss engine built by the Hoover, Owens & Rentschler Company, Hamilton, Ohio, with the usual pumps and feed-water heater. The boilers are teed directly into a 14-in. steam main, from which a 6-in. supply pipe leads over to the engine. The stack is located outside of the building and connected with the four boilers by means of a sheet-iron flue running across the tops of the boiler fronts, as shown in Figs. 2 and 4. The stack is 127 ft. high and built in two sections; the lower section, of 58 ft., is 6 ft. in diameter, and the upper section, of 69 ft., is 5 ft. in diameter. The engine has a 20-in. high-pressure cylinder and a 36-in low-pressure cylinder with a stroke of 48 ins. The fly-wheel is 20 ft. in diameter with a 48-in. face, and the normal speed of the engine is 80 r.p.m.

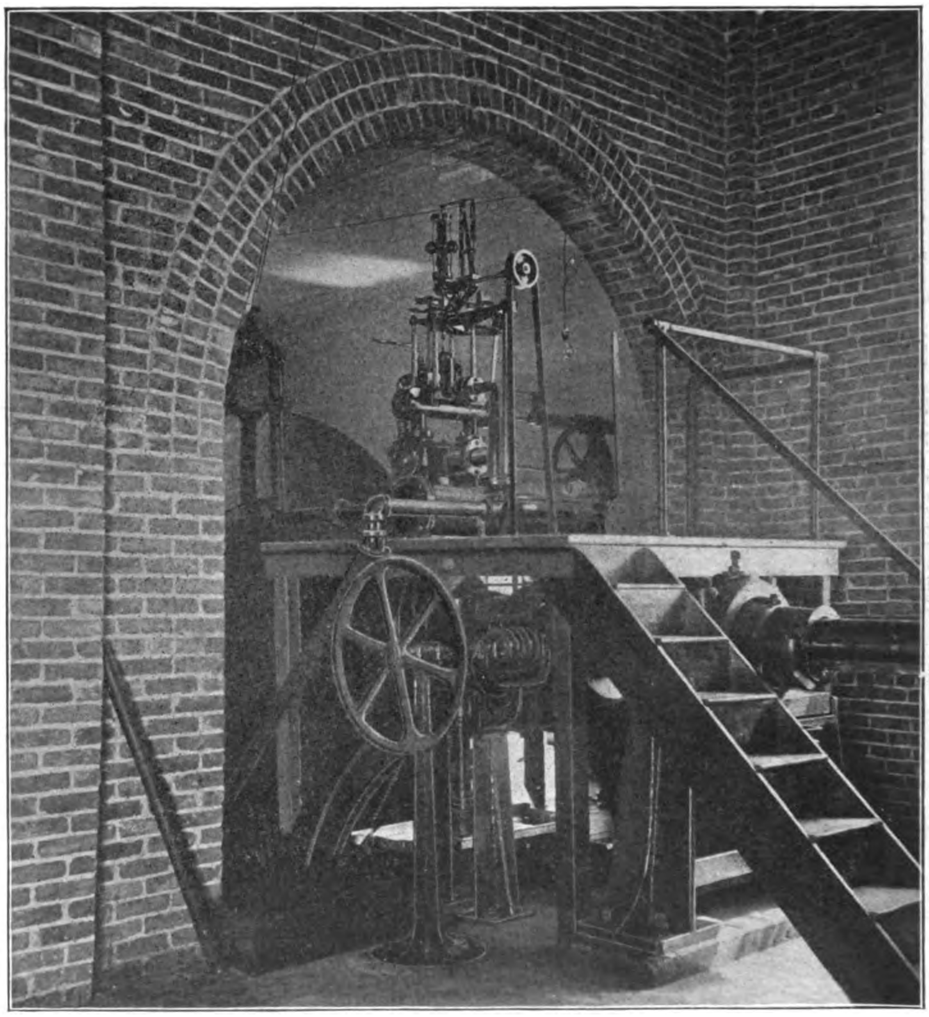


FIG. 5.—WATER-WHEEL GOVERNOR AND ENTRANCE OF MAIN SHAFT.

A line-shaft runs along almost the entire length of the south side of the engine room and is directly driven by the water wheel through a friction clutch. The shaft is provided with pulleys at proper intervals for belt connection to the generators, the booster and the engine; thus far it has not been found necessary to use the steam plant at all. Each of the pulleys is on a separate section of shafting which is connected with the neighboring sections through the medium of friction clutches. The total length of the shaft is 87 ft.

The generators are four-pole General Electric machines of 300 kilowatts output each, and they are direct-driven from the ends of a short counter-shaft through the medium of friction clutches, the counter-shaft being belt-driven from the main line-shaft. The armatures are 36 ins. in diameter and 20 ins. long parallel to the shaft, and run at 400 r.p.m., which gives a peripheral speed of 3770 ft. per minute. The booster is a 150-kw. bipolar machine of the old Edison type and raises the voltage from 550 to about 700-800 volts, according to the load.

The switchboard is of marble, divided into three panels. The central panel contains two Thomson recording wattmeters, one for the booster and one for the main generators; the left-hand panel is the booster panel and carries one 800-volt Weston voltmeter, one 1000-ampere cir cuit-breaker, one 400-ampere Weston ammeter, a single-pole single-throw 500-ampere switch, and two single-pole double-throw 500-ampere switches. The right-hand panel is the generator panel and contains two 500-ampere Weston ammeters, two 1000-ampere circuit breakers, four 500-ampere single switches and the equalizer switch. The generator voltmeter is located near the water-wheel governor for convenience in adjusting the governor. Fig. 6 is a diagram of the connections on the back of the board.

The economy of water-power operation is strikingly brought out by this plant. Formerly the road was supplied with power from the steam-driven station of another company at a cost of 2¼ cents per kilowatt-hour, of which it is safe to assume that 1¼ cents was the actual cost of generation. With the water-power plant the cost per kilowatt-hour is reported as being 0.048 cent, or about one-tenth of the best steam performance on record, and about 40 per cent of the estimated cost at the former source of supply.

The track is laid with 50-lb. rails and oak and cedar ties. The ties run 2640 to the mile, and the roadbed is ballasted with gravel. Atkinson 9-in. rail-bonds are used at the joints. The trolley wire has a figure 8 cross-section equivalent to two 000 wires. It is suspended by Jewell slings from gas-pipe brackets mounted on 30-ft. poles, which are spaced 52 to a mile. A feeder of 350,000-circ. mils cable extends from Toledo 4½ miles along the north side of the river, and another feeder of the same size extends 3½ miles on the south side and crosses the river through a mile of submarine cable. The Bowling Green branch is supplied through two feeders, one 6½ miles long and the other 7 miles long, each feeder consisting of two 0000 wires. From Bowling Green to Jerry City, 5 miles distant, one 0000 wire serves as a feeder. The entire line is equipped with a block-signal system.

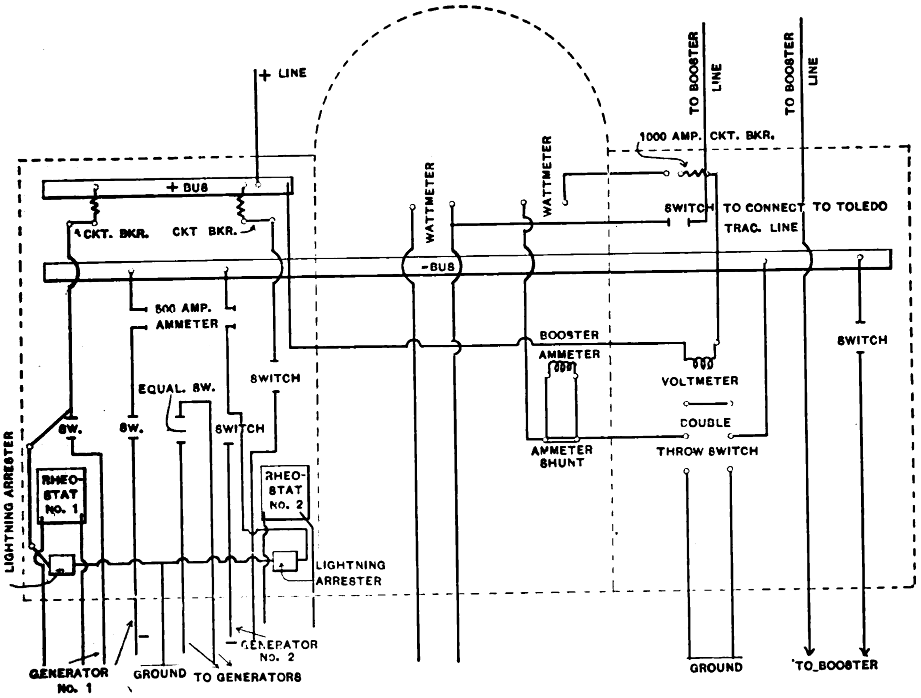


FIG. 6.—DIAGRAM OF THE SWITCHBOARD CONNECTIONS.

The rolling stock consists of 22 cars, 8 of which are open, 12 closed and two of the so-called accommodation type. Fourteen of the cars have 50-h.p. motor equipments, four have 70-h.p. motor equipments, and four have 100-h.p. equipments. The average service requires nine cars during the week with an interval between cars of half an hour; on Sundays 18 cars are operated. All of the cars are provided with handbrakes only.

Many attempts have been made by the railroad interests of Ohio to have the state authorities abandon the canals, but the use of these canals for water-power to drive electric light and power machinery has operated for the preservation of the canals in good condition. The possibilities, however, of these sources of power have been by no means fully utilized. The plan of using the canal as a source of power for the road just described originated with Charles A. Denman, general manager of the system, under whose efficient supervision the plant was installed.

CUTTING STRUCTURAL IRON BY MEANS OF THE ELECTRIC ARC.

BY J. R. CRAVATH.

It is now coming to be recognized—in Chicago at least—that under certain conditions the electric arc affords the cheapest and most convenient method of cutting structural iron work or vault steel. In the reconstruction or alteration of modern office buildings it sometimes happens that some of the steel girders forming the frame of the building must be cut to accommodate the necessary changes, and likewise the changes sometimes made in bank safety deposit vaults necessitate the cutting of the vault linings. Often the girders are in a place difficult to get at with saw or drill and the cutting through of modern vault walls can only be done by annealing a spot and then drilling it, and so on "ad nauseam" to the man doing the job and the people waiting for him to finish it. Under either of the conditions just mentioned the electric arc demonstrated itself by far the quickest, most convenient and economical method if current is available.

A year and a half ago six 18-in. I-beams in the New York Life Building, Chicago were burned off in one-tenth of the time that would have been required to saw them, the saving in time required to finish the job being one of the main objects of the contractors for the alterations in the building. The expense was also less than for sawing. Recently six 14-in. I-beams were burned off in a similar way in the Rookery at Chicago. Numerous jobs of electric burning to accommodate new vault doors and get at broken locks have also been done.

To do successful burning on structural steel a current of not less than 350 amperes should be used, though smaller currents will do the work, only more slowly. Vault steel is more fluid when melted and does not clog as does structural steel. The carbon with which the arc is drawn is best about 1½ ins. in diameter and is, of course, connected to the negative side of the circuit. A heavy aluminum band bolted around the carbon has been found to be the best method of attaching the conductor cable; to this band a wooden handle is attached. For resistance to steady the arc a sufficient length of No. 18 German silver wire to absorb all but 70 or 80 volts, at the required rate of current flow, wound on a wood frame and put in a pail of running water is a cheap and convenient method, and the one usually employed.

When connecting up to do such work it must always be remembered that since the positive side is connected to the structure to be worked on, the insulation resistance to ground of the source of supply should be investigated and any grounds on the negative side of the supply circuit must be removed. When drawing from an Edison three-wire central station supply (in which case the neutral is usually grounded intentionally or otherwise), the work should be done between the neutral and negative wires. To protect the eyes of the operator a sheet-iron box, over the arc heavily lined with asbestos, and having an insulated hole for the carbon, is generally used. Where it cannot be used, as in corners, a large sheet of thick asbestos board with a hole through it for the carbon is substituted. The operator should always wear double dark glasses, and if he observes the simple precaution of never looking directly at the arc there is no danger whatever. If he does look at the arc for anything more than the briefest interval he may be tolerably sure of a pair of very painful eyes the following night, even though he may feel no ill-effects immediately afterward. The cutting down by the arc is, of course, exceedingly rough and jagged, but for the purposes mentioned that is a small drawback compared with the saving in time and labor.

Engines and Generators at the Paris Exposition

In the French Power-House.

In the power houses of the Paris Exposition there are to be seen examples of every type of engine and dynamo, all direct-connected, except the Charon gas engines, which drive by means of belts small dynamos for local lighting and for the operation of the cranes. Previous articles have given some idea of the diversity of designs shown. One of the most unusual designs among the alternators is that by J. J. Rieter, of Winterthur, who makes use of an internal stationary armature and an external revolving field. The ring-shaped yoke is turned on the outside, presenting the appearance of a large flat pulley, and the poles project radially on the inside toward the armature. This construction gives a strong flywheel effect, and the magnetic pull is opposed to the centrifugal force, instead of being added to it as in the case of most flywheel alternators.

A French engine-generator set presenting many points of interest is that exhibited by Crepelle & Garand, of Lille, and Decauville, of Petit-Bourg, the former supplying the engine, the latter the dynamos; Fig. 1 shows the combination. The engine is a cross-compound with Corliss valves, and runs condensing normally at 70 r.p.m. The high-pressure cylinder is 28 ins. in diameter and the low-pressure 52 ins., the stroke being 63 ins.; the cylinders are steam-jacketed. The normal output of the engine is 1200 horsepower. The horizontal type of engine, such as this is, is open to the objection that the cylinder wears out of round; but in the Crepelle & Garand engine the wear is reduced to a minimum by providing a cylinder bushing of extra hard iron, which is forced into the outer barrel, and by extending the piston rod through the back cylinder head and supporting it in an adjustable bearing on the cylinder head.

The valve stems have no stuffing boxes, but are provided with hard steel rings which bear against cast-iron faces on the inside of the steam chest, forming steam-tight joints. The connecting rods have a length equal to five and one-half times the length of the crank, and are solid at the crank-pin end, this construction affording greater strength than can be obtained with a strap. The cross-head is provided with an adjustment for wear so that the piston-rod may be kept perfectly central. The shaft carries at the center a flywheel, and on each side of it the armature of a 10-pole direct-current generator. The cranks are steel forgings and are pressed on the shaft and keyed; the crank pins are driven in by the hydraulic press. The cranks are set 90 degs. apart.

The generators are of the well-known Thury pattern. Each is capable of 400 kilowatts output, furnishing 1600 amperes at 250 volts, or a total of 3200 amperes for the two machines. As offsetting in some degree the extra expense incurred by installing two 400-kw. machines instead of one 800-kw. machine, it may be remarked that this arrangement allows of coupling the two dynamos in parallel, or in series for a 500-volt distribution or a three-wire 250-volt system. For the Exposition circuits the e.m.f. required at the main switchboard is 235 volts. The armature hub is in two halves, bolted together and keyed to the shaft. The sheet-iron core is built up on bronze supports; the laminations are separated from each other by layers of paper, and ventilation spaces are provided for cooling.

The drum-wound armature has 625 (?) conductors of rectangular cross-section, .255 in. by .275 in., connected to a commutator 6 ft. 6 ins. in diameter, with a brush tread 10 ins. wide. The brush-holder studs are carried on a cast-iron ring held on four supports, one of these being fitted with a small pinion which gears into teeth cut on the outer edge of the ring. The brushes may by this means be moved through a considerable angle for adjustment, the pinion being moved by a key or wrench applied to a hexagon head. The weight of each armature, with the hub, is 12½ tons, and one machine complete weighs 29 tons. The field bore is 9 ft. 4½ ins. and length of armature under the poles 13½ ins.

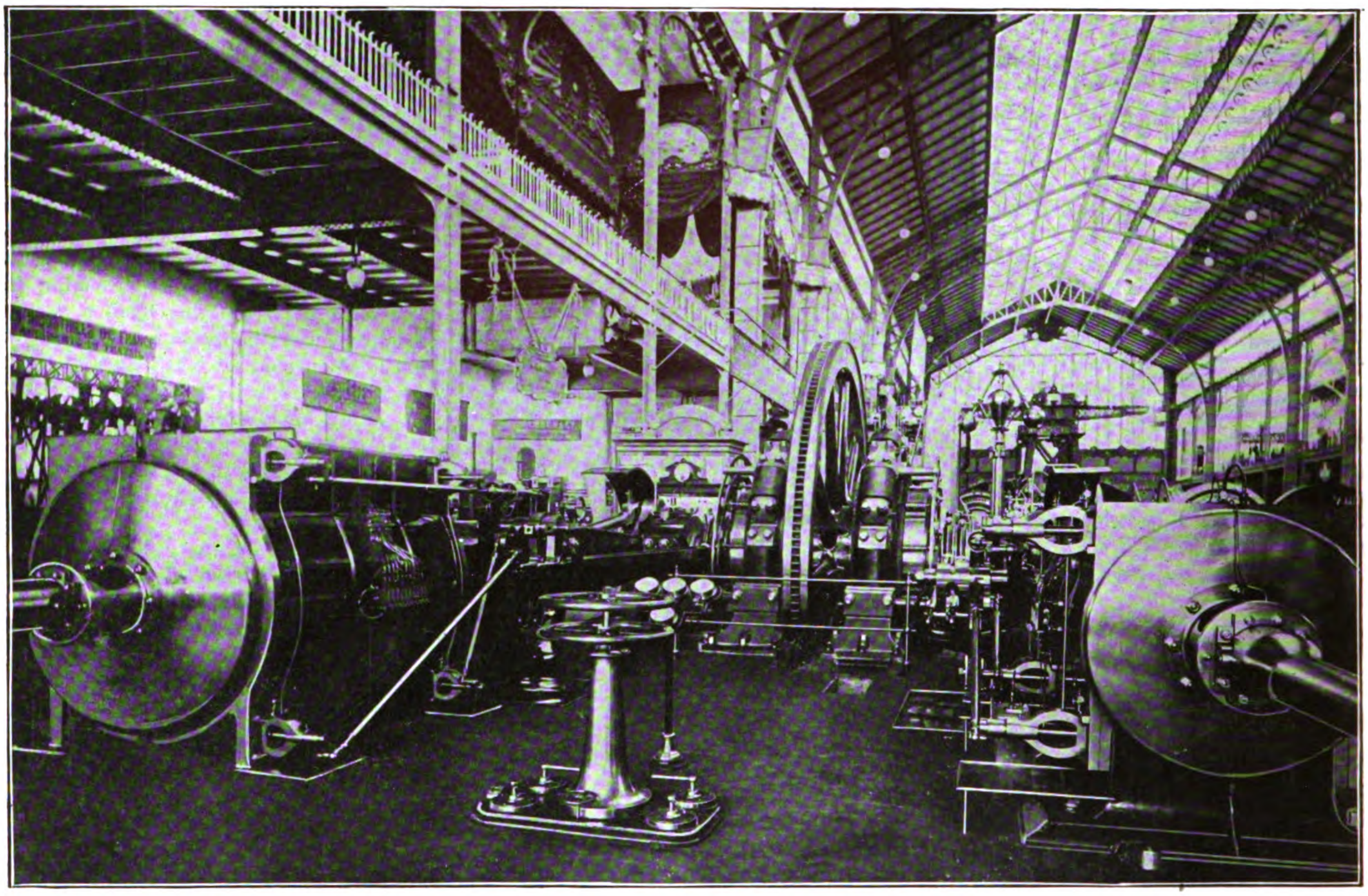


FIG. 1.—CROSS COMPOUND CREPELLE & GARAND ENGINE DRIVING TWIN DECAUVILLE GENERATORS OF 400 KILOWATTS EACH.

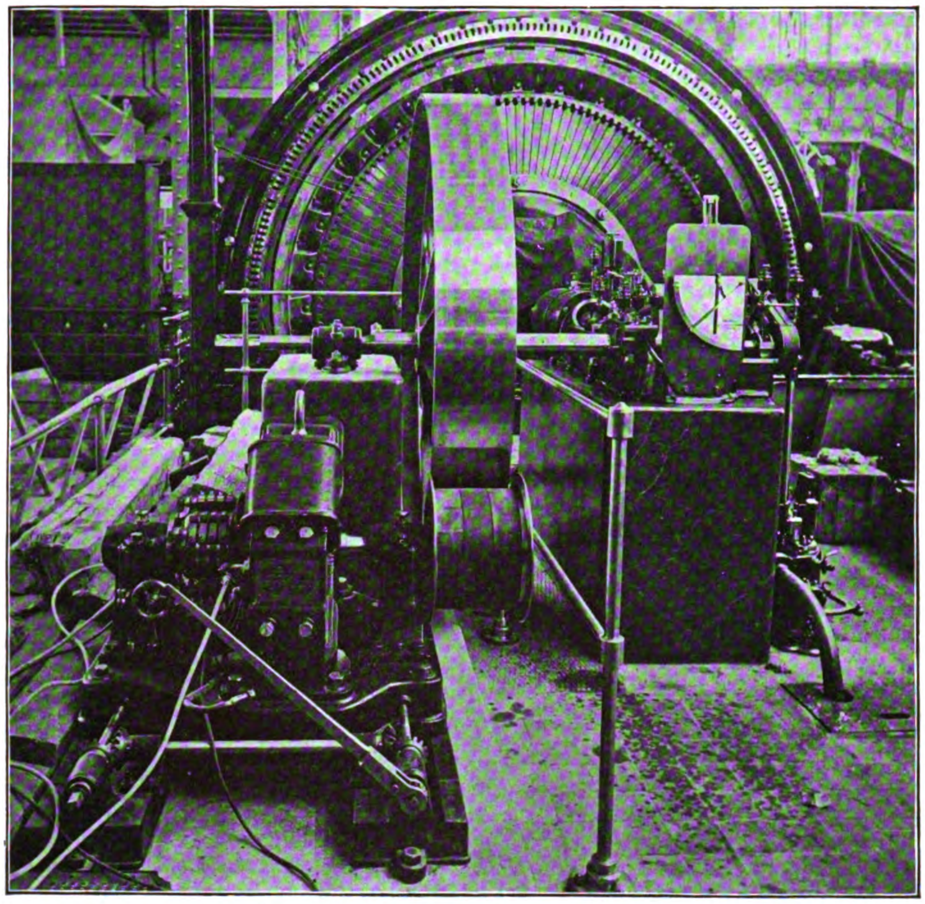


FIG 3.—25-H P. PIGUET ENGINE AND GRAMMONT DYNAMO.

An engine of about the same horse-power as that above described, but of the vertical type, is exhibited by the Alsacian Society of Belfort and illustrated by Fig. 2. The engine is of the two-cylinder vertical compound type, with Corliss valve gear, and runs at 70 r.p.m. The high-pressure cylinder is 31½ ins. and the low-pressure 53 ins. in diameter, with a stroke of 47¼ ins. Under a steam pressure of 120 lbs. this engine develops 1100 to 1200 horse-power. The shaft is in two parts and is supported on four main bearings, outside of these being located the dynamo at one end and the flywheel at the other; outboard bearings are also provided. The flywheel, 18 ft. 8 ins. in diameter, weighs 31 tons and is built in two parts, bolted together. The cylinders are both steam-jacketed, the high-pressure cylinder jacket taking steam from the main supply pipe; the high-pressure exhaust goes to the low-pressure cylinder through its jacket. A jet condenser is used, and the air pump, which is directly behind the engine frame at the high-pressure end, is driven by a link connected to the cross-head. A double-seated valve in the exhaust pipe allows the exhaust to pass into the air when the condenser is not required.

The dynamo is a 550-volt direct-current machine with an internal stationary field and outside revolving armature of the Siemens & Halske type, the brushes bearing directly upon the bars of the armature winding. The winding is built up of U-shaped conductors with straight bars across the outer surface, the bars being of extra large cross-section in order to provide for wear. Copper gauze brushes are used and are held in movable brush-holders on a star-shaped rocker arm which may be adjusted angularly by means of a small gear and locked in any position. This dynamo is intended to ultimately supply current at about 600 volts for a five-wire lighting system in the northern part of Paris; the current output of the machine is about 1250 amperes.

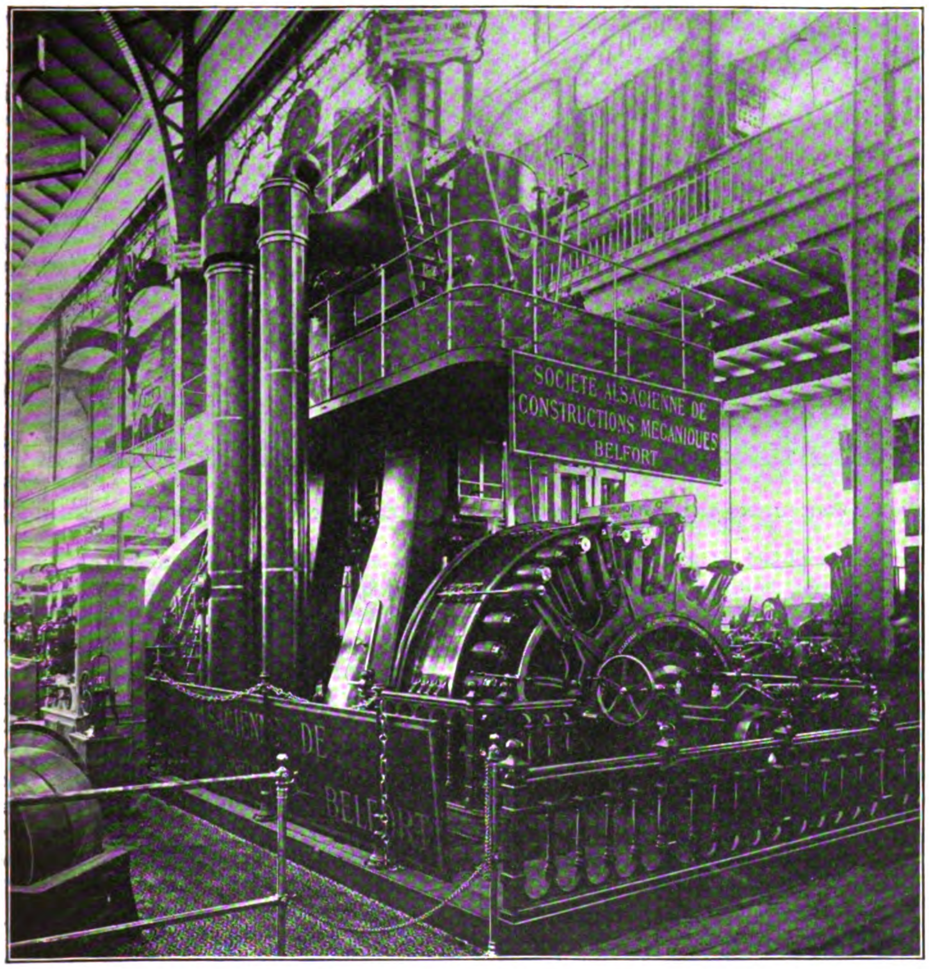


FIG. 2.—800-KW. GENERATING SET OF THE SOCIETE ALSACIENNE.

The field magnet frame is bolted to the engine uprights, and carries 12 poles of cast steel with extended shoes, the length of pole being 17¾ ins. and cross-section 325 sq. ins.; the wire has a section of 21 square millimeters. The resistance of the field coils, in series, is 24 ohms. The armature has 189 turns per pole, of bars 60 square millimeters in cross-section. The armature core is built up of soft steel laminae with sheets of paper between; the outside core diameter is 12 ft. 6 ins. and the radial cross-section 100 sq. ins. It is supported on 39 bolts secured to corresponding arms of a cast-iron spider which is keyed to the shaft. With the load of 1500 amperes at 500 volts the machine gives an efficiency of 95.5 per cent, the losses being as follows:

	Per cent.
Excitation	1.4
Copper loss in armature winding	1.6
Hysteresis and eddy currents	1.2
Brush and air friction	0.3
	4.5

Among the French engine builders are several instances of single cylinder construction, some of which have been described in previous articles. One of the most prominent manufacturers is Piguet & Co., of Lyon, who have four engines on exhibition, all constructed on essentially the same lines, but of 25, 40, 60 and 800 horse-power respectively. The smallest and the largest of these are together in the main engine room of the Champ de Mars, in the French section. The 25-h.p. engine has all the features of the large one, even to the direct driving of the air pump and feed-water pump by a connecting rod from a crank disc on an extension of the engine shaft.

The Piguet engine is horizontal, and provided with a main valve and a cut-off valve working in the ordinary manner on a flat seat. At first sight it appears strange that this design, which is very common for a small engine, should be applied to an engine of 800 horse-power, but the manufacturers are satisfied that the advantages of this construction outweigh the disadvantages, and continue to use exclusively the slide valve and single cylinder. The 800-h.p. engine drives a 600-kw. Grammont alternator, furnishing three-phase current of 2400 volts e.m.f. and a frequency of 50 cycles a second. The revolving field has 64 poles. The chief feature of interest in connection with the alternator is the compound exciter by Hutin & Leblanc, driven by a gear from the main shaft.

The engine cylinder is 33½ ins. in diameter and the stroke is 43 5/16 ins. At a speed of 95 r.p.m. this gives a piston speed of about 685 ft. per minute. The cylinder is made in two parts: an inner casting bored out to take the piston, and provided with steam ports; and an outer casting forming the steam jacket. The outer casting is further provided with mineral wool covering and an outer envelope of blued sheet steel secured in place by brass straps. The main valve has a constant travel, and regulation is secured by varying, by means of the governor, the travel of the cut-off valve. The governor is driven by two chains from the main shaft, or in the smaller engines by a belt from the crank disc on the auxiliary shaft, and varies the travel of the cut-off valve by changing the position of a link connection. The piston is a single casting; this with the object of avoiding damage due to loosened bolts when a follower plate is used. Two shafts are used: the main shaft carries the revolving field of the alternator, and the smaller shaft, with two independent bearings, drives by means of a crank the air pump and feed-water pump, both being driven by one connecting rod.

The 25-h.p. engine exhibited by this company has a cylinder 7⅞ ins. diameter and a stroke of 15¾ ins. The speed is 180 r.p.m. A small continuous current four-pole Grammont dynamo is driven from the flywheel, by means of an Evans friction pulley. A special form of dynamometer, shown very clearly in Fig. 5, is used to take the place of an indicator and is supposed to be less likely to get out of order. This dynamometer consists of a quadrant marked with scales for steam admission and speed of rotation. Two movable scales are set by hand, a radial one being clamped at the figure on the quadrant representing the speed, and a vertical scale being set to a figure on the radial scale representing the steam pressure. An index controlled by the position of the cut-off valve shows on the vertical scale the output of the engine in horse-power.

The Power Plant at Vincennes

One of the most important exhibits at the Exposition, in point of utility and efficiency, is the generating outfit in Machinery Hall, Vincennes. The engine of this set is a 300-h.p. tandem compound, built by the Ball Engine Company, Erie, Pa., and the generator is a 200-kw. multipolar machine built by the Bullock Electric Company, Cincinnati, Ohio. The engine has 15 and 25-in. cylinders, of 18 ins. stroke, and is supplied with steam at 250 lbs. pressure from Morrin's Climax boilers (Clonbrock Boiler Company, New York). This engine, which is the only American-built one here, has been giving magnificent service ever since it started on July 1, and has amply vindicated the claims of American engineers for a high figure of merit in their product.

The steam chests of the two cylinders are on opposite sides, which permits the valve motions to be simplified. The valves

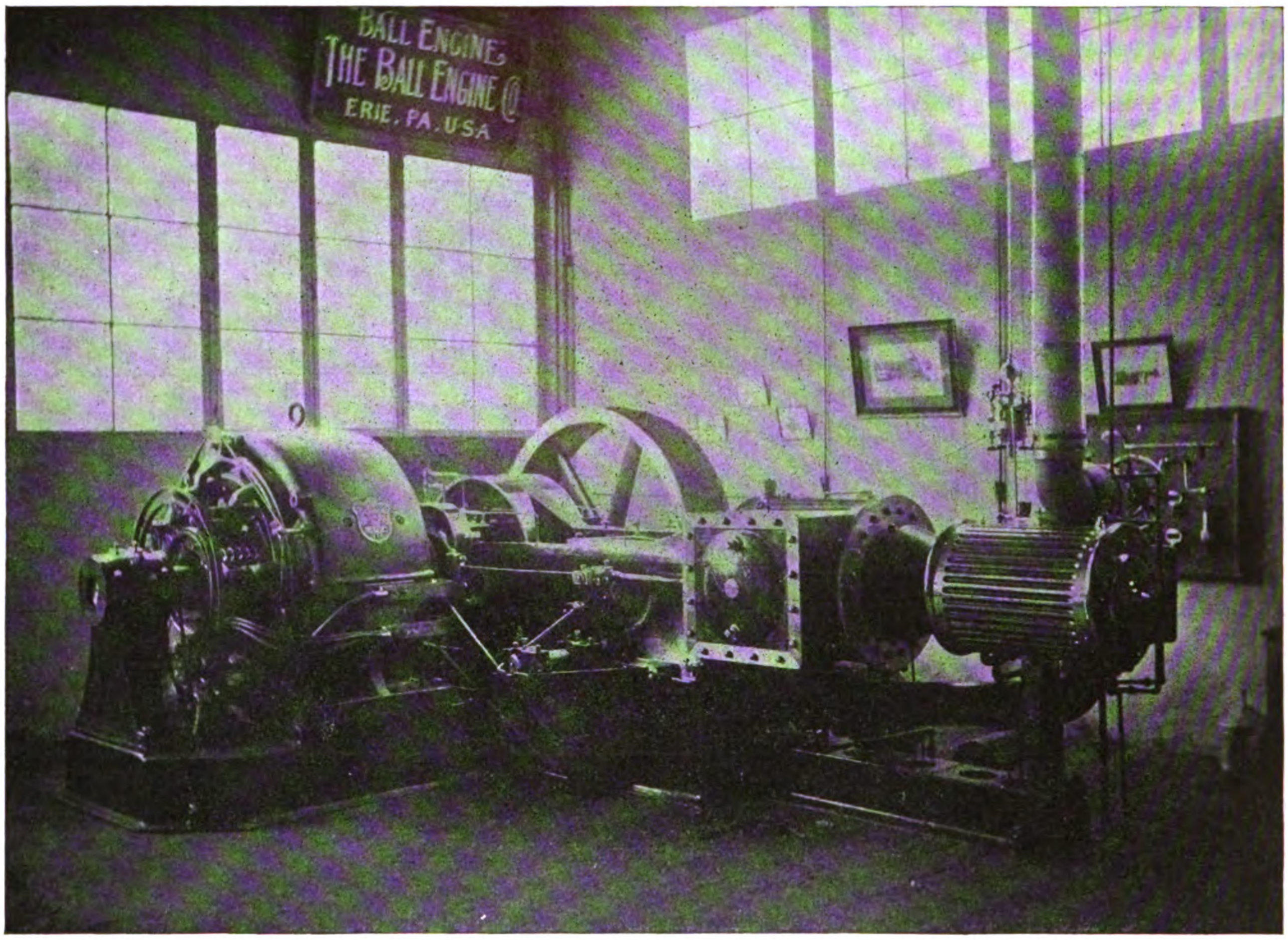


FIG. 4.—BALL ENGINE AND BULLOCK GENERATOR CONSTITUTING THE POWER PLANT OF THE AMERICAN MACHINERY HALL, VINCENNES.

themselves are of the well-known Ball two-part telescoping type, held against the seat by steam pressure in such a way as to entirely prevent leakage of steam along the wearing surfaces. The divided head between the cylinders is a convenient arrangement, as the two pieces of which it is composed may be removed by taking out a few bolts. The strain is taken up by tongued and grooved joints, relieving the bolts entirely.

The Bullock generator is an 8-pole machine with a cast-iron field-magnet ring and laminated pole-pieces, furnishing current at 240 volts with no load, an overcompounding of 10 volts giving 250 volts at full load. The field excitation is, however, kept down so as to give 225 volts with normal load, as this is more suitable for some of the motors in the building. The average load is about 300 amperes, but runs up sometimes to 500 amperes. The brushes are of the well-known reaction type, firmly held on brush-holders electrically connected by two heavy bands of copper wound over with cord to prevent accidental short-circuiting. The connections to the series coils are heavy copper bars whose terminals are brought to a board fixed to the frame of the machine, the shunt terminals are brought to a board fixed to the frame of the machine, the shunt terminals being on a second board. A very slow longitudinal motion is given to the brushes whereby they are moved along the face of the commutator, back and forth, the motion being derived from double worm gearing actuated by a belt from the shaft. The whole of the brush-holder yoke is moved in this manner. The frame supporting the motor is in one piece with the sub-base under the engine, making a solid unit of the whole set. Current from this generator is used chiefly for power purposes in connection with the operation of machine tools and the Shaw 30-ton crane which serves the building, but there are also a few lights run here and in the adjacent Transportation Building. The generator has shared with its running mate, the Ball engine, the triumph of continuous operation under trying conditions without a hitch or balk of any kind.

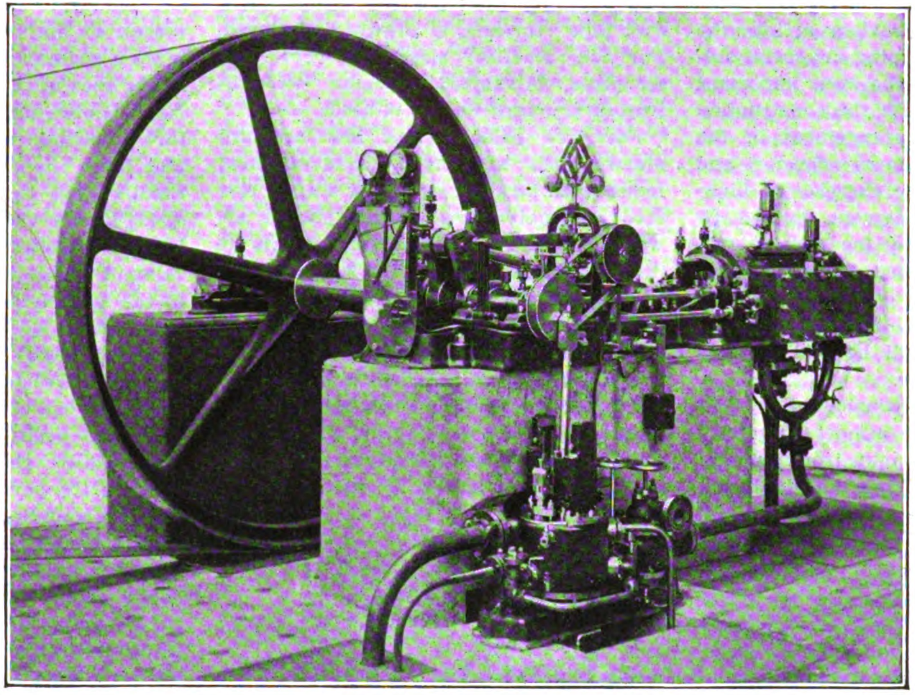


FIG. 5.—SIDE VIEW OF PIGUET ENGINE AT THE PARIS EXPOSITION.

This power plant will be the last piece of machinery to be removed from the United States Building after the close of the Exposition in November, as the traveling crane is dependent upon it for the supply of power for loading the exhibits on the cars.

THE ESSENTIALS OF A GOOD STOKER.

BY A. L. HARRISON.

Mr. C. B. Miller's questions in the September issue relative to mechanical stokers are of a leading character, and to answer them fully would require a too lengthy article. I will, however, try to give the best general idea I can as to the essential points of a satisfactory stoker. The first essential is coking capacity, which must be in proportion to grate area. One lineal foot of coking or feed-plate surface to four square feet of grate is about the least permissible ratio if you want to secure complete combustion, which is the only remedy for the smoke nuisance, and the only way to secure the full benefit of the heat available in the coal, or the full benefit of the economy due to clean heating surfaces free from soot.

The second essential is that the furnace be so arranged that the volatile gas will be both extracted and burned as the coal is being stoked or pushed over the coking or feed plate onto the grate. Ample length of coking surface and the arrangement of the furnace so as to secure complete coking and instantaneous complete combustion of the volatile gas in the coal are both essential to economy and smokelessness. Again, the furnace should be so arranged as to be capable of burning anywhere from 15 to 40 lbs. of coal per square foot of grate, according to the character of the coal and the strength of draft available.

Third, in addition to the proper proportion of coking capacity to grate area and a proper arrangement of the furnace to secure perfect combustion, there must also be such arrangement of the furnace as will permit keeping the fire clean and in condition to do continuous work with minimum attention on the part of the attendant and without the admission of considerable extra quantities of air.

Fourth, to secure durability, the form and arrangement of the grates and other parts exposed to the fire must be such as to present the least possible surface to the heat and the greatest possible surface to the cooling effect of the air used to supply the fire with the necessary oxygen for combustion.

Those who have looked up the practical workings of stokers and have a decided preference for any one make can specify that the boilers are to be equipped with that make of stoker furnace, of suitable size. But it will be necessary that the specifications provide that the boiler be of such width as to permit the use of a furnace of "suitable size." The wisest way to get at this is to take counsel of the stoker manufacturer first. Tell him what power you require, the coal to be used, the draft and other conditions, and let him tell you what width, height, etc., will be most suitable to secure the results desired.

Results depend in much larger measure on the furnace than on the boiler used. There are many plants fitted with good stoker furnaces that are short of what they might be because the boilers were were bought without proper regard for the furnace, and the furnace man has been obliged consequently to do the best he could under conditions which fixed, unnecessarily, unfavorable limitations. The man who specifies or buys a boiler without due consideration of the application of the furnace, like the architect or engineer who plans a building without proper consideration of the space required for the proper installation of the mechanical appliances needed, will have to do as he can instead of as he would, because he began at the wrong end.

SOURCES OF ECONOMY.

There are three principal sources of extra economy due to intelligent use of a judiciously selected stoker furnace as compared with a hand-fired furnace, or a poorly-devised form of stoker; viz., an increase in the efficiency of combustion; that is, the heat units produced per pound of coal used, and a consequent increase in the initial temperature on the boiler-heating surface; a reduction of the waste of heat by admitting less unnecessary air to the fire; and an increase in the number of heat units transmitted to the water by reason of the absence of soot and consequent cleaner surfaces of the boiler. A saving of fuel and heat is also effected by the use of a self-cleaning stoker which thus maintains a constant, clean, live fire over the entire area of the grate.

There are other advantages, such as readier steam, steadier pressure, use of low grade coal, less hard labor on the part of fireman or attendant and, in plants of sufficient size (1000 horse-power or over), coal-handling machinery, and in some cases ash-handling machinery also, can be used with considerable additional economic advantage.

If a judicious selection of a stoker furnace be made, it will pay a good return on the increased cost in any full-duty plant whether of large or small size. Any bituminous coal may be used, but the advantages of a good stoker furnace are greatest where low grade coal is used or is available. When anthracite or any specially low grade fuel is to be used, to secure satisfactory service the stoker should be specially adapted for that purpose.

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STEAM PIPING AND PIPE FITTING.

BY WILLIAM D. ENNIS.

As intimated in a previous article, the installation of steam piping in central stations is by no means the least important work in connection with the construction of the plant. The arrangement of the piping to secure maximum efficiency and flexibility, requires the exercise of high-grade engineering judgment backed by considerable experience; for reliable service, the materials must be of the best grade and the methods of fitting in accord with recognized practice. The scope of the present article will be restricted to materials and methods.

The materials to be considered are few in number and of the utmost simplicity in construction. Wrought iron pipe, in sizes from ⅛ in. to 17 ins., and in larger sizes for special work, is commonly used for steam, exhaust steam, and in the smaller sizes, for water. It is made in three thicknesses, the standard weight pipe being ordinarily suitable for working steam pressures up to 150 lbs. Extra strong pipe is the heaviest ever used in central station work and is suitable for any pressure likely to be carried in a steam plant.

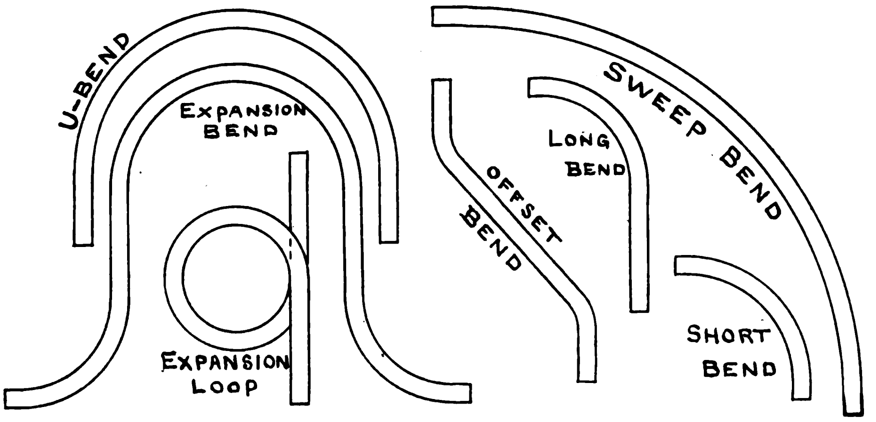

FIG. 1.—FORMS OF PIPE BENDS IN GENERAL USE.

Cast-iron pipe is used for water, exhaust steam and occasionally for live steam. In the two former instances what is known as standard weight flanged water pipe is of ample strength.

For live steam header and blow-off connections, in which cast iron is sometimes used because of its cheapness, the castings should be of especial thickness with long radius fillets, and should be made of a very fine, close-grained metal (gun-iron). The number of joints is diminished by the use of cast iron in such cases and this forms a considerable advantage in high-pressure work. It is somewhat more troublesome to erect than work made up in wrought-iron pipe with cast flanges and standard fittings, for the reason that after the measurements are obtained for a given piece, a pattern must be made and the fitter must wait for a shipment from the foundry.

In certain cases, as on long lengths of water pipe, this objection does not hold. The cast-iron pipes can be made in full lengths up to the last piece and straight pipe of any length for the filling-in piece can be quickly obtained.

Brass pipe is used for hot water. In power plants the heavier grade, with iron pipe threads, is always employed. For the smaller sizes of cold water pipes, galvanized or black wrought iron of standard weight is used.

For free exhaust and low pressure steam, pipes are often made of sheet metal with straight or spiral seams, riveted and galvanized. These should always be made up with flanged joints at intervals of about 12 ft., the flanges being galvanized and riveted to the pipe. The principal advantage of sheet metal pipe for low pressures is its lightness.

The principal standard fittings used are too familiar to require discussion. Special castings should never be used when any of the standard forms of fittings are applicable. Bushings should be used only for low-pressure work and in small sizes, reducing ells, tees, couplings and crosses being preferable.

Bent pieces of wrought-iron pipe have been introduced lately in power work and at the present time it is considered poor design to use a fitting for making a turn when bent pipe will answer. Some of the forms which may be obtained are shown in Fig. 1. They cost very little, if any, more than the old construction with pipe flanges and fittings. The great advantage obtained by their use is the reduction in the number of joints, the greater radius of turn and their lightness. Bent pipe has been principally used in high-pressure steam work but it should be of even greater value for exhaust and water pipes. Extra strong pipe gives much better results than the ordinary weight in bending; the standard pipe is apt to wrinkle in the rolls. The maximum length obtainable in a single piece is 20 ft. Expansion bends, expansion loops and U-bends should be made of copper when over 6 in. in diameter.

In power-station work straight-way or gate valves have been universally adopted for use in lines of water, exhaust and the larger sizes of steam piping. The reason is that such a valve when open gives a passage area fully or nearly equal to the area of section of a pipe of the same size. Globe and angle valves are used for throttling and regulating purposes and have the advantage of being more readily kept tight and repaired than a straight-way valve. In small sizes and for low pressures, the more familiar gate valve in which the hand-wheel is fastened to the stem is generally used. The type shown by Fig. 2, in which the spindle rises through the hand-wheel, is a stronger valve and has the advantage that the upper end of the stem or spindle indicates the position of the gate and approximately the amount of opening through the port.

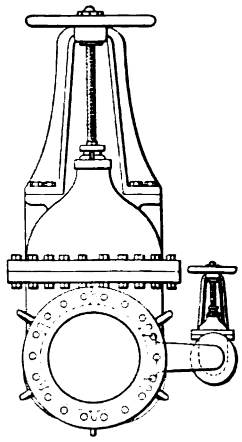

FIG. 2.

Valve spindles are made of steel or bronze, the latter being preferable where there is liability to corrosion, as in a boiler room. Valve seats are made of babbit metal or bronze, the former not being desirable for temperatures above 250 deg. Various makers build valves for a great range of working pressures. What are known as "standard weight" valves are supposed to be suitable for 100 lbs.; "extra heavy" valves are limited to 250 lbs. The Chapman Valve Manufacturing Company makes a line for 125-lb. work. The Crane and Ludlow Companies have a medium weight valve designed for 150 lbs. pressure, which is heavy enough for most power plant work. The Lunkenheimer Company makes its "Victor" gate valves of the same weight for both standard and extra heavy use, but increases the thickness of the flanges in the latter case. The Jenkins Brothers globe and angle valve is made in one uniform weight for all pressures up to 200 lbs.

When a large valve is closed, with steam pressure on one side of it, the friction of the disc or gate against the opposite seat is so great that it is impossible to open it. For this reason valves larger than 6-in. are usually provided with a by-pass vaive cast on or in the body, as in Fig. 2; so that the pressure can be brought to both sides.

Various methods of making joints with lengths of pipe, fittings and vales are in use, differing according to the pressure to be carried and other circumstances. It should be remembered that the "other circumstances" are often the determining factors. In all pipe work, the location of a piece of material is often of more consequence, in calculating the required strength, than the pressure. Pipe systems are not only conductors of fluid, but they may act in parts as beams, girders, columns and the like, in order to support other parts. Moreover, considerations of convenience will often dictate a stronger or different joint from that which the condition of safety alone would require.

For pipes, valves and fittings there are three ordinary systems of connecting: Screwed, flanged, and bell. The cheapest and simplest form of construction possible is with right and left screwed fittings. In such work the pipe is put together from start to finish without filling-in pieces, the final joint being made with a nipple or other fitting having a right-hand thread at one end and a left-hand thread at the other end. This can only be done where there is sufficient spring in the pipes to permit of spreading and drawing together the last joints. It is practicable only for small sizes and low pressures, and is now rarely used.

The ordinary screwed system, put together with right-hand fittings, and having the final connection made by means of a union, is suitable for high or low pressure, according to the weights of the materials. For sizes above 3 in. the union should be replaced by union flanges, which are cheaper. On long lengths of straight pipe, the pipe joints may be made with couplings, but union or faced flanges are preferred for power work.

In all high-grade piping, flanged fittings, valves and pipe flanges are used, and the joint is made without any strain or possibility of wear. Any part of the work can be taken down by simply removing the bolts. The bearing can be strengthened after the pressure has been brought upon it. Such a joint is used ordinarily on pipes above 2 in. in size carrying live or exhaust steam, but flanged material is made for certain purposes down to this size or smaller.

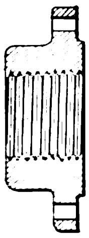

FIG. 3.

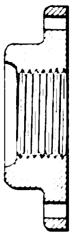

FIG 4.

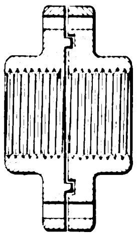

FIG. 5.

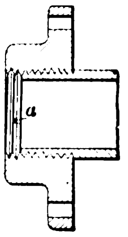

FIG. 6.

Various patterns of flanges, and methods of attaching and connecting them, are in use. In the form shown by Fig. 3 the face of the flange is made with a boss so as to limit the bearing surface to the inner line of the bolt holes. This construction results in a bolt action similar to that of the load on an overhanging beam. In Fig. 4 a calking recess is cut in the back of the flange hub. In Fig. 5 what is known as the tongue-and-groove joint is illustrated. Here we have an overhanging beam with a rigid strut.

The common method of "making on" a flange is to screw the pipe end through as far as it will go, binding the joint. Experience teaches the machine man to gauge very closely the distance that the pipe end will fall short of the flange face (a, in Fig. 6),* and consequently the amount to "allow" or deduct from the end-to-end measure of the pipe. Sometimes the pipe end is "peined" into the flange, Fig. 7, after making up. This has the objection that it is apt to loosen the grip of the threads back under the hub.

Another construction is to screw the pipe through the flange, and then to face off both pipe end and flange in a lathe or boring mill. This makes an ideal bearing surface, extending from the inside of the pipe to the bolt holes. In order to screw the pipe through the flange, however, some departure must be made from the standard of drilling and tapping the flange, and this makes it somewhat more difficult for the workman to judge the proper amount for "making up." The consequence is that if he has allowed too much, and the flanges are the specified distance face to face before the threads are tight, the latter are not likely to be made tight. Properly made, it is one of the best forms of flanged joint. The common method, Fig. 6 is equally good if the flange is "made on" in a machine, and made as it should be.

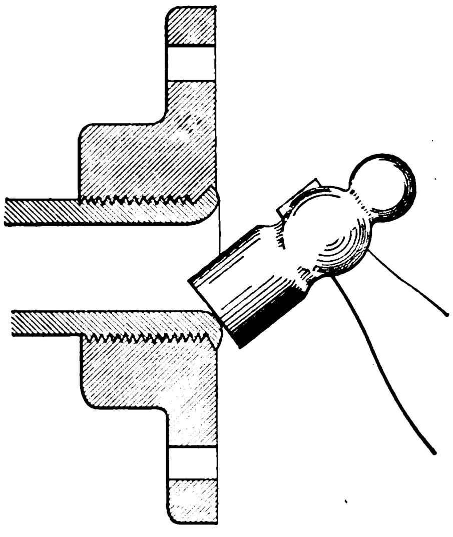

FIG. 7.—PEINING THE PIPE END.

As far as the form of the flange itself is concerned, the manufacturers have evolved patterns for various pressures that leave little to be desired. Hubs should be made deeper for heavy work than for heating pressures. As to the special points illustrated, the boss on the flange face (Fig. 3) is a good idea. Tongues and grooves are annoying, for the reason that it is necessary to take down a whole line of pipe to disconnect a single joint. Moreover, these features must be adopted on valves and fittings where they are used on pipe flanges, which makes the cost of construction somewhat higher.

For very high pressures, special methods of jointing are used, one of which is illustrated in Fig. 8. This is the Van Stone pipe joint, designed by Mr. C. Van Stone, of the Walworth Manufacturing Company. A special grade of pipe is used, and the turned-over ends, a, b, have ground bearing faces. The flange is held in place by a wrinkle raised in the pipe at c. Mr. George I. Rockwood introduced a joint similar to this some years ago, but he riveted the flange to the pipe. Another form that has been proposed is made like the Van Stone joint, but the pipe ends are upset before rolling over, and no flanges are used excepting the pipe ends themselves. Riveted flanges, in which there is no thread, the flange hub being riveted to the pipe, are occasionally met with in the larger sizes. All of these special joints are bolted to cast fittings and valves in the usual manner.

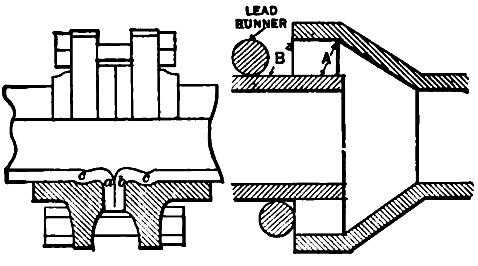

FIG. 8.—SPECIAL HIGH-PRESSURE JOINT.

On cast-iron pipe, two forms of joint are used. The first is made with flanges cast on, the faces of the latter being made smooth, bossed, or tongued and grooved, as required. Flanged joints are necessary on cast-iron pipes carrying steam, exhaust, or water under high pressure or suction. The condenser injector-pipe in a power plant is usually so connected.

The other form of joint is known as the "bell" end. This is made tight by calking with lead and hemp.

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An International Electric Railway is about to be built between France and Italy, the necessary survey of the line having been completed by D. Luis Rouviere. The Italian terminus will be at Lerida, and the line will traverse the valley of the Aran, the descent into the Upper Garonne being effected at a slope of 6 per cent. A tunnel 2⅜ miles long will connect the two international stations. The traction will be by electricity, the necessary power being procured from falls along the Garonne and the Nogulra Rebagarzana, two rivers that already provide electric energy for various electrochemical and metallurgical factories in the neighborhood.

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* The engraver has reversed the sketch and shown the pipe entering from the wrong side.

STORAGE BATTERIES IN ELECTRIC RAILWAY POWER STATIONS.

BY EDWARD L. REYNOLDS.

The steady improvement of electric railway equipment has called out no feature which can show more strength in its development than the storage battery, and the many advantages resulting from such installations in the power stations or at points far out upon the line—near the terminations of feeders—have been repeatedly pointed out in various articles appearing in the columns of this paper. It is not the intention of the present writer to deal with this subject in its entirety, but to cite briefly some specific results which are now being obtained in the operation of several electric railway stations, thereby showing clearly the exact advantages which may be in general expected from the installation of a storage battery to operate in conjunction with the power generators.

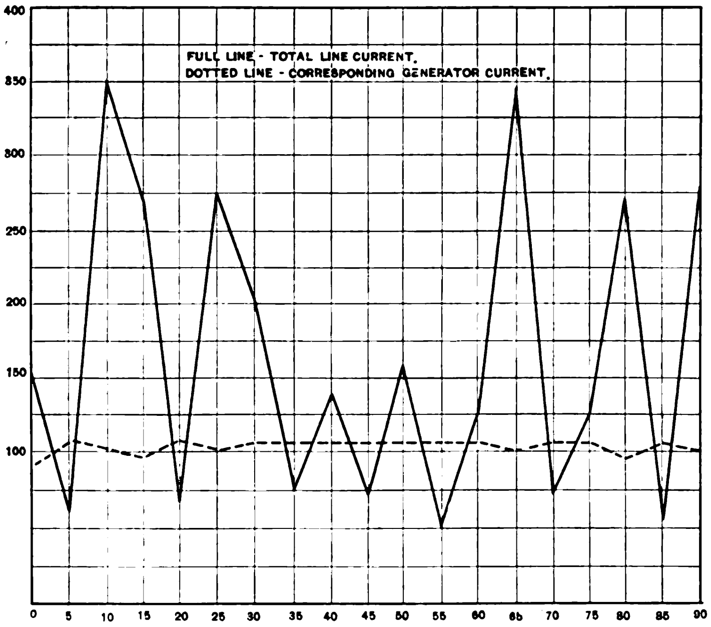

FIG. 1.—CURVES FROM PEEKSKILL PLANT.

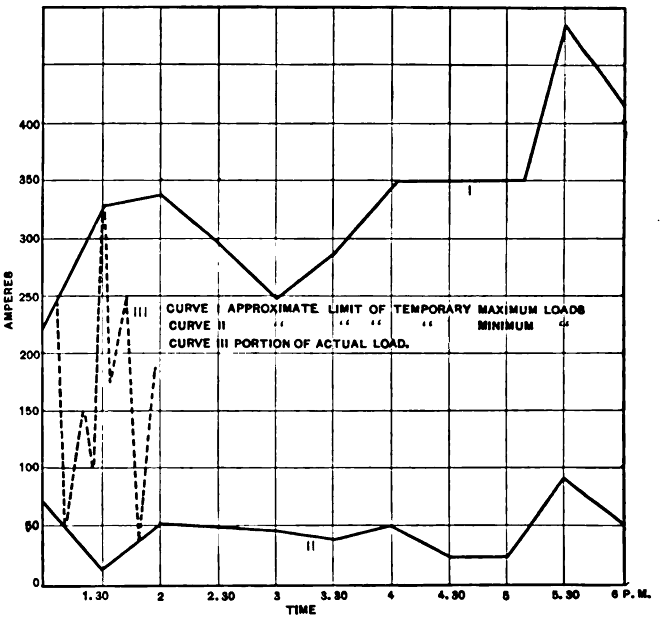

FIG. 2.—CURVES FROM EASTON PLANT.

At Peekskill, N. Y., the Traction Company has in service a battery of 262 "type F-9" Chloride accumulator cells. In connection with this is operated a belt-driven differentially-wound booster, the functions of which are to render the charging and discharging of the battery automatic. The generators comprise one 60-kw. unit and one 120-kw. unit. The 120-kw. generator is kept in reserve ordinarily, and used on holidays when the load is exceptionally heavy. The road is about 5 miles long and covers many long 8 per cent grades. The usual schedule covers from three to five cars.

During the evening of March 30, 1900, simultaneous readings were taken from the generator ammeter and the battery ammeter. These readings were made every five seconds for a short period, from 7 o'clock in the evening mentioned. The results are given in Table I and are also plotted in the form of curves in Fig. 1.

The first point that impresses itself is the evenness of the load upon the generator while the total line current fluctuated between 50 and 350 amperes. It is apparent from this why it is possible to operate such a system as the one under consideration with a 60-kw. generator. Were the battery not there to relieve the dynamo of the sudden calls for current, it would be necessary to operate generators aggregating at least 200 kw. In other words the current delivered by the generator during heavy load is but 30 per cent. of the total current required. The difference in economy between two engines, one driving a 60-kw. dynamo at a full constant load, and one driving 200 kw. of generators fluctuating between practically nothing and full load, is certainly an item of importance. Unfortunately, it has not been possible to learn what the fuel saving is, since the road has never been operated without the battery. The curves, however, indicate forcibly that a very great advantage in efficiency must be realized in this case. It seems generally admitted that the efficiency of a modern railway engine is affected adversely by such an irregular load as this at least 33 1/3 per cent as compared with that which should be expected from a constant load representing the same amount of power.

TABLE I.

Total Line Current.	Generator Current.	Battery Current.	
		Charge.	Discharge.
150	90	0	60
60	110	50	0
350	100	0	250
270	95	0	175
68	110	42	0
280	100	0	180
200	110	0	90
70	110	40	0
135	110	0	25
70	110	40	0
160	110	0	50
50	110	60	0
125	110	0	15
340	100	0	210
70	110	40	0
125	110	0	15
270	95	0	175
60	110	50	0
285	100	0	175
50	110	60	0

In addition to the saving in operating expenses the maintenance account of the machinery and the liability to break down are materially reduced, for not only is less machinery running, but that which is doing the work is relieved from the racking of the great changes in load.

The readings were taken at the period of heavy load for the day, hence the battery was discharging considerably more than it was charging; or, to express it differently, the battery was not only smoothing out fluctuations at this time, but was doing "peak" work.

Another railway system upon which a storage battery is used is that at Easton, Pa. The conditions are some what different in this case, principally because of the fact that the one generator used (a 500-kw. belted machine) is considerably larger than the average load demands. This surplus capacity was installed because it is expected that the load will grow much larger in the near future. The curves in Fig. 2 were formed by connecting together the points of maximum current for each half hour and by doing the same with the minimum readings. That is, these curves represent the limits between which the ammeter needle at any given time might swing. Thus the dotted line shows a hypothetical load line for a short period. These curves are presented as a somewhat unusual method of plotting the fluctuating nature of a railway load. The maximum and minimum readings of each interval were taken within a very few moments of each other.

The recent use upon long roads of alternating-current transmission with rotary converter substations has had the effect of broadening the storage battery field, and a considerable number of such roads are equipped or being equipped with batteries. The results which may be expected from the use of the batteries upon a system of this character are represented by curves shown in Fig. 3. These curves are plotted from 5-second readings taken at the rotary substation of the Union Electric Railway at Dover, N. H. The lower curve, representing the total current used by the motors, shows a fluctuation between 15 and 335 amperes. In spite of this wide variation, the load upon the rotary (as shown in the top curve) is practically constant at 90 amperes. The middle curve shows the work which was done by the battery, and represents the fluctuations in load above and below the average current demand.

Now, by the consideration of a railway plant in which a battery is not installed, one can approach the subject from the other side, which will perhaps give a clearer idea of the battery advantages. For this purpose the writer has selected a plant near New York. There are four generators, each belted to a horizontal compound engine; three are 300-kw. machines and one is a 200-kw. The average day of 24 hours for, say, nine months in the year, shows three loads. The curve of Fig. 4 represents the heavy load occurring three times a day (morning, noon and evening) and lasting about one hour each time. The load of the remaining portions of the day between early morning and 12 o'clock midnight is about one-half the amount shown in Fig. 4. The third load referred to is that carried between 12:30 and 4:45 a.m. This load averaged about 150 amperes and is nearly constant, consisting of incandescent lights.

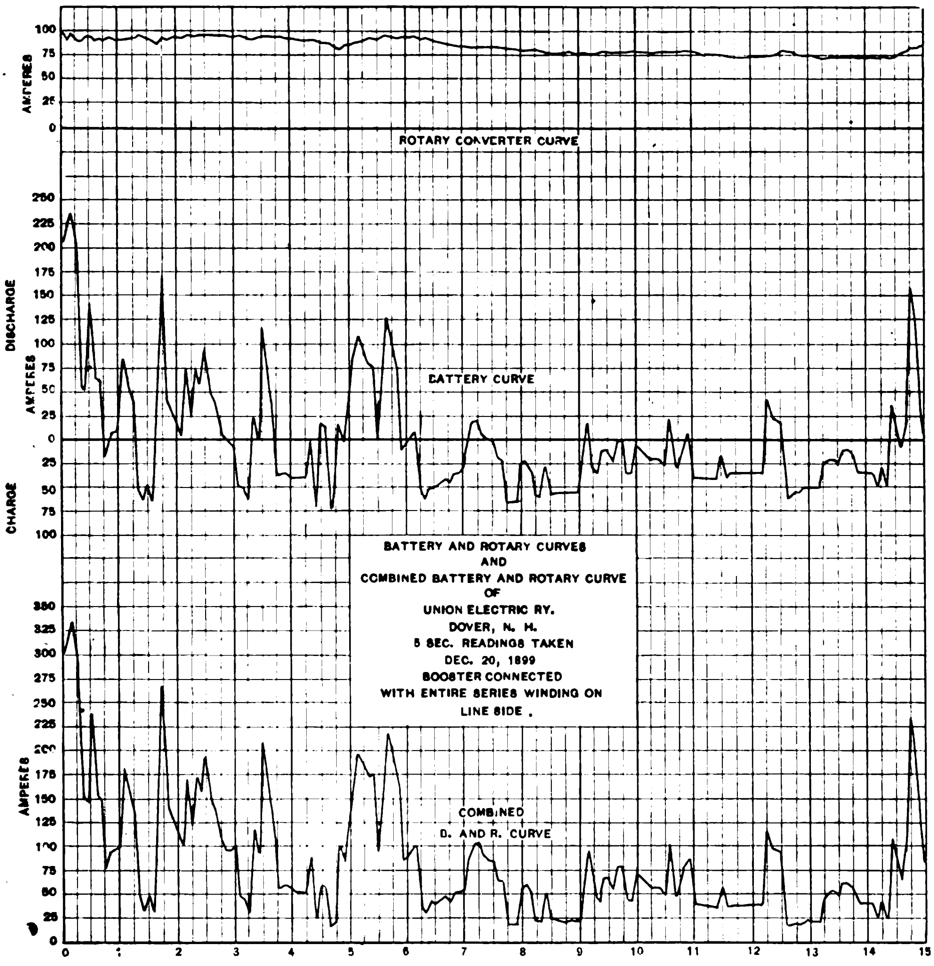

FIG. 3.—CURVES FROM ROTARY CONVERTER PLANT AT DOVER, N. H.

From the foregoing it appears that, although the maximum fluctuations of current during the light-load day hours are considerably above the capacity of one 300-kw. generator, yet the average is well under. Now, as a fact, for the nine months of the year during which the above conditions govern, two 300-kw. generators are run from 5 a.m. to 1 o'clock the following morning—20 hours a day. Were a battery installed of sufficient capacity to relieve the generators of the fluctuations above the average load, then one generator would carry the entire day load up to 1 o'clock in the morning with the exception of the three times during the day, when the heavy load shown by Fig. 4 must be carried.

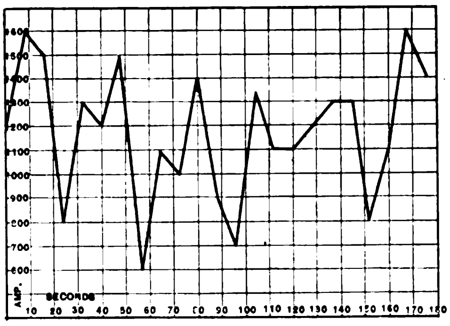

FIG. 4.—A 1½-MINUTE RECORD.

During the three remaining months which represent the winter period, the load is sufficiently large to necessitate the running of three 300-kw. generators. The conditions of load during this season are not well known to the writer, but it is fair to assume that the battery would enable one machine to be shut down just as has been shown above.

Under these conditions it is not assuming too much to say that one-third of the coal now burned per year could be saved by the battery. The present coal consumption averages about 16 tons a day, which for 365 days at $3 a ton amounts to $17,520; one-third of this is $5,840. The labor could be reduced by one oiler at $8.75 a week and one coal passer at $10 a week, adding to the saving $975 a year, and making a total annual saving of $6,815. This does not include the decreased maintenance expense for the steam plant, since this would be almost equaled by the maintenance of the battery, thus rendering the saving in this direction of too small an amount for consideration.

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THE INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS.

The fifth annual convention of this association was held in Pittsburg, September 25 to 28 inclusive, the sessions being held in the Monongahela House. The convention was called to order by President Wm. Brophy, of Boston, and Mr. S. U. Trent welcomed the visitors to Pittsburg in the name of the municipality President Brophy responded to the welcome speech in an appropriate manner and then read his annual address, in which he discussed most ably the duties and responsibilities of municipal electrical officials. Mr. J. P. Barrett, of Chicago, next made an interesting address, giving a brief history of the fire alarm and telegraph systems of the United States, after which the roll was called and some routine business was transacted. At the afternoon session President Brophy read a paper on "The Benefits to be Derived from the Association," which was made the subject of a full and interesting discussion by the members present.

The second day's session began promptly at 9.30 a. m., when President Brophy read a paper by Mr. J. L. Morgan, of Kansas City, who was unable to be present. Mr. D. R. Walker, Chief of the Electrical Bureau of Philadelphia, made an interesting and lengthy address on the work which has been performed by his bureau and which he characterized as the most comprehensive that has been accomplished in this country. A paper on "Electrical Connections," by Mr. Frank C. Mason, of Brooklyn, was then read by Mr. Morris W. Mead. Mr. Mason's paper was followed by one on "The Trials and Troubles of Instituting and Enforcing Municipal Inspection and Control," by Mr. M. G. Canfield, of Grand Rapids, Mich. Mr. Canfield prefaced his remarks by endorsing the National Electrical Code as far as it goes, but stated that it does not go far enough for the purposes of municipal inspection, as municipalities were as much interested in the safety and protection of life as in the protection of property. For this reason, he urged, it is necessary to formulate rules applying to outside work, so that with ordinary precaution the lives of linemen, firemen, and others would be protected as much as possible.

He favored the licensing of persons engaging in electrical work and the exaction of a bond of, say, $1000 to protect the license, but he opposed requiring the licensee to pay a fee for his license, which he construed as an unjustifiable obstruction to the earning of a living on the part of the licensee. Referring to the work of municipal inspectors, he touched upon the difficulty which was always encountered when it became necessary to remodel obsolete equipments, and advocated the policy on the part of municipal inspectors of giving reasons for what they required to be done without overdoing the thing by posing as bureaus of information. He suggested that inspectors should take a record of the number of times any installation is visited, keeping the data of the visit and a summary of the condition of the installation, so that the office would be able to furnish any desired information as to the condition of any installation in that city at short notice. The discussion of Mr. Canfield's paper took up the remainder of the morning session.

At the afternoon session a paper on "Automatic Fire-Alarm Systems," by Mr. Chas. Burger, of Boston, was read, and this was followed by the reading of a short contribution from Mr. W. H. Baker, vice-president and general manager of the Postal Telegraph-Cable Company, on the subject of "Carrying High and Low-Potential Conductors Upon the Same Poles." Mr. Baker pointed out that the juxtaposition of wires carrying high and low-potential currents must always be a source of much danger to life and property despite all practical safeguards, and argued that the two classes of conductors should be completely and absolutely separated.

With Mr. Baker's contribution on high and low-potential wires was communicated the sad intelligence of the death of the wife of Mr. Francis W. Jones, chief electrician of the Postal Telegraph-Cable Company, who was down on the programme for a paper on the subject discussed by Mr. Baker, but was prevented from preparing it by the illness and death of his wife.

At the morning session of the third day of the convention, after the transaction of some routine business, the election of officers for the ensuing year was held, and resulted as follows: Morris W. Mead, Pittsburg, Pa., president; J. T. Zeliff, Paterson, N. J., first vice-president; Burt C. McAllister, Bradford, Pa., second vice-president; R. E. Moran, Memphis, Tenn., third vice-president; F. P. Foster, Corning, N. Y., secretary; Adam Bosch, Newark, N. J., treasurer; and M. J. Donohue, Niagara Falls, N. Y.; Capt. Wm. Brophy, Boston; J. W. Aydon, Wilmington, Del.; Frank C. Mason, Brooklyn, N. Y.; F. G. Boyd, Baltimore, Md.; W. Y. Ellett, Elmira, N. Y.; G. F. MacDonald, Ottawa, Ont.; M. G. Canfield, Grand Rapids, Mich.; and M. A. Michaels, Peoria, Ill., Executive Committee.

A humorous communication was read from Mr. J. L. Morgan, formerly city electrician of Kansas City, Mo., in which he explained that he was no longer an active member of the Association, as the office of city electrician had been abolished some six months before. Referring to some of the conditions under which the city electrician labors, Mr. Morgan said that "his employers consist chiefly of the mayor and a city council, or probably the city council and a mayor. Characteristic curves of the mayor may be more or less easily plotted, but no one can foretell the vagaries of the city council." The ethics of the profession, he continued, demand that dignity should be omnipresent, but dignity and aldermen are strangers. "In vain you attempt to discuss with an alderman plans which you have for bettering the electrical condition of the city, or money that you have saved by the elimination of electrolytic electrolysis. The alderman dismisses such a proposition with a gesture and brings you down to earth with a jar by telling you that he has a friend whose door-bell doesn't work or that his electric-light meter is working over-time. If he doesn't want a door-bell fixed or his meter shunted, he probably wants a city telephone placed in his hall or a city arc lamp in his parlor, or perhaps he only wants his gasoline stove repaired. When the influential member introduces you to his brother-in-law and confides to you that he is to be your chief or sole assistant, that he is a first-class kalsominer and in a few days will learn to be a good electrician, you must cheerfully accept this as an axiomatic proposition. Never show the slightest annoyance; if you don't like him take him out and connect him up with the alternating-current primaries. This is not crime, but philanthropy. Endorse unreservedly any and every proposition advanced by any member at any time or at any place. It is also wise to express an eagerness to personally assault any person, not a councilman, who has the slightest views opposed to those of the aforesaid member." Coming down to a serious vein, Mr. Morgan suggested State control as a remedy for the more or less grotesque conditions pertaining to municipal systems, contemplating the appointment of a chief electrician who would have deputies to supervise the work not only in large cities, but in small ones as well. This arrangement, he pointed out, would also remedy the existing defect that small cities and towns have practically no expert protection.

It is to be regretted that the convention was held so late in the month as to preclude anything like a complete report of its deliberations. In this connection it may be well to state that the discrimination between the papers mentioned in the foregoing paragraphs was not a matter of choice, but was determined solely by the fact that these were the only copies available at the time of going to press.

MISTAKES IN THE RATING OF INCANDESCENT LAMPS.

A 16-c.p. lamp is such a common article of commerce and in such general use that we all recognize it when we see it, or think we do, either by the size of its bulb or the length of the filament, or both. Very few people go beyond such mechanical identification except for the extra assurance they gain by a look at the manufacturer's label. Some, indeed, presume to tell that a lamp is of a given candle-power by looking at the brightness of its filament or by considering the general lighting of a room; but it need scarcely be said that an estimate formed by such a method is utterly worthless, since one is too much influenced by contrasts in brightness, or deceived by the temperature at which a given filament is burned, to really tell anything at all about the candle-power.

That a 16-c.p. lamp should be one which gives a light equal to that of 16 candles in the direction in which the light is useful seems a natural and fair definition. A little careful observation of lamps as they are installed shows that at least 85 to 90 per cent of those used are put in place with base upward, or tipped end downward, and it is the light which comes from this tipped end of the lamp which is useful. In cases where the lamp is installed in a different position, either the lamp is subordinated to some artistic feature of the electrolier, or the lamp is installed "side on" to better keep it out of the way. So it comes about that the light we ought really to want to know about, the light we ought to measure, is that coming out of the end of the lamp. Or at least it is sure that, if we call the axis of the lamp a line through it from the middle of the base up to the sealed-off tip, the light of value is that coming into space below a plane perpendicular to the axis, half way along its length. We can never use more light than this, since for satisfactory lighting the sources must be above us, and in real service we make use of much less, as will be presently shown. Should we take the average candle-power of all the light rays into space below the imaginary plane just defined, this would be called the mean hemispherical candle-power, just as the average candle-power of all the light rays given by the lamp in every direction is called the mean spherical candle-power.

The common use of reflectors is evidence that the ordinary incandescent lamp does not give as much light below it as is required there. Is there then a bad light distribution from the lamps? An examination of modern lamps will show.

There are five different types of filament in use to-day by various prominent lamp manufacturers, and in most cases a filament type indicates the product of a certain manufacturer who has adopted that as the one used in his standard lamps. These typical filaments are enough different from each other to show interesting individuality. I have classed them as follows:

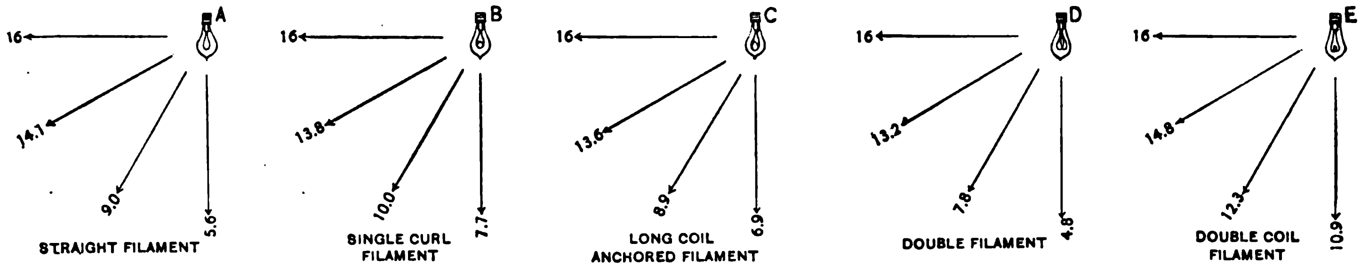


FIG. 1.—SHOWING CANDLE-POWER EMITTED BY DIFFERENT SHAPES OF FILAMENT IN DIFFERENT DIRECTIONS.

A. Straight U-shaped filament; a type rapidly passing out of use.

B. Single coil filament; type much used, having a circular loop in the filament midway of its length.

C. Long curl anchored filament; a type different from type B in that the loop is long in the direction of the lamp axis and is anchored to the part of the lamp where the leading-in wires pass through the glass.

D. Double filament; a type which uses two filaments like type A, set so the current passes through them in series, the filaments being in planes approximately parallel.

E. Double coil filament; a type like B, except that there are two turns in the coil instead of one.

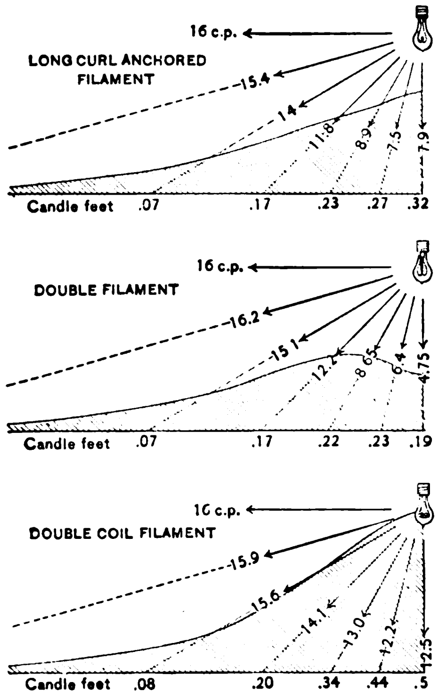


FIG. 2.—SURFACE ILLUMINATION.

Besides being typical in the matter of general form, the light distribution observed from these various filaments is also typical. It is, however, considerably influenced by the exact relation of different dimensions in the filament itself used by particular firms; as, for example, the diameter of a coil or the spread of the filament shanks. The results of the tests, therefore, would have been departed from somewhat if different makes of lamps had been used in the tests.

Fig. 1 shows average candle-power values from lamps of each of the different types. The arrows indicate the direction from which the candle-power was measured and the number gives the candle-power. These values are true averages of the types shown. In the average struck no "freak" lamps were included. The five types were each represented by the product of some prominent lamp maker. All the lamps were rated at 16 candle-power, all were in the standard bulb used by the manufacturer of that type, and, as it happened, all were 3.5-watt 110-volt lamps.

TABLE I.

Filament.	Light in Given D'rection in Per Cent	
	Vertically Downward	30° from Vertical.
Type E........	100.	100.
" D........	44.0	63.4
" C........	63 7	72 4
" B... ...	70.6	81.3
" A..........	51,4	73.2

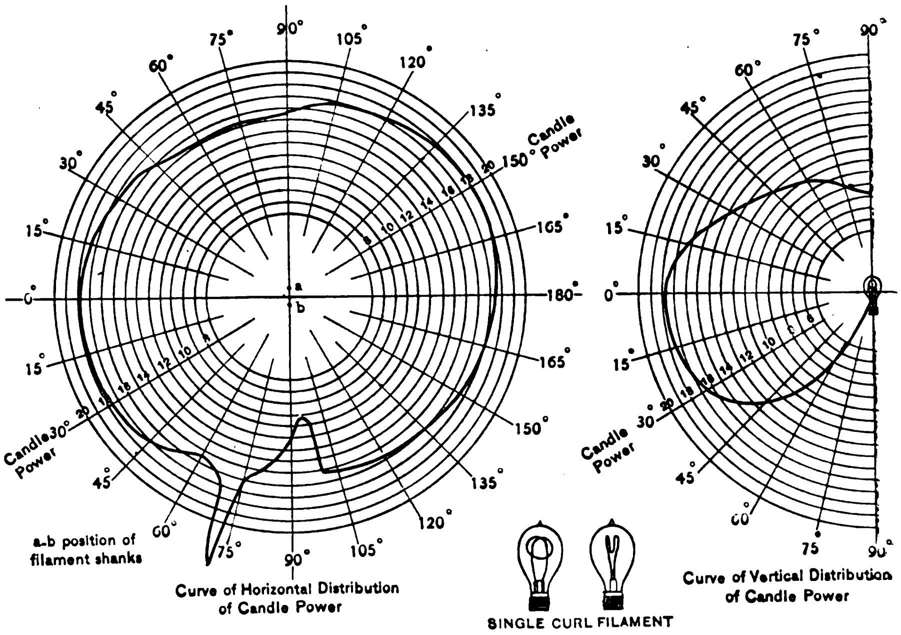


FIG. 3.—HORIZONTAL AND VERTICAL DISTRIBUTION OF SINGLE COIL FILAMENT.

The tests show that a 16-c.p. lamp is very different in the candle-power it gives in various directions and very different in a given direction with different types of filament. That lamp which gives most useful light is undoubtedly the best. Hence there is no question but that the type E, double coil filament is far better for general lighting purposes than any other. Table I gives a relative amount of useful light from filaments of the different sorts, expressed in per cent of the light given by the double coil filament (type E).

A large amount of light streaming from the end of the lamp is only useful if it produces a proper illumination. In Fig. 2 is plotted the illumination of a level surface 5 feet below a 16-c.p. lamp of different makes, the distribution being shown one way out from the lamp only. A single representative lamp was taken of each of three important sorts and the candle-power as marked on the diagrams determined for the light given in each of the directions shown by the arrows. The illumination was then calculated in candle-feet, and this plotted vertically from the base line. The solid curved line bounding the shaded area runs through the points so found, and all vertical distances from the base line give the amount of illumination there. Some of the values found are marked. Thus, for the long curl anchored filament .32 candle-foot is procured at the surface illuminated by the ray giving 7.9 candle-power, .27 by the ray giving 7.5 candle-power, etc.

A first look at the diagrams would seem to indicate that the double filament lamp is best, since it gives more uniform illumination than either of the others. In any case, we need not concern ourselves with the light received from rays making an angle greater than 45 degs. with the vertical, since up to this angle a circular area 10 ft. in diameter, above the center of which the lamp hangs, is being lighted. Under the lamp the light is most valuable, and there we want to get most light. The double-coil filament turns out then, to be by far the best form. If in lighting an interior the lamps were hung separately and placed about 6 ft. apart, the evenness of the illumination produced would be about the same for lamps having double-coil filaments, or lamps having long-curl anchored filaments; but the amount of illumination procured from double-coil filaments would be so much greater that they are much to be preferred. We are assuming all along that 16-c.p. lamps, as the manufacturers call them, are in use. If lamps were placed 15 ft. apart, the distribution of light with double filament lamps would be very good if an even distribution is desired; but the average illumination would be low.

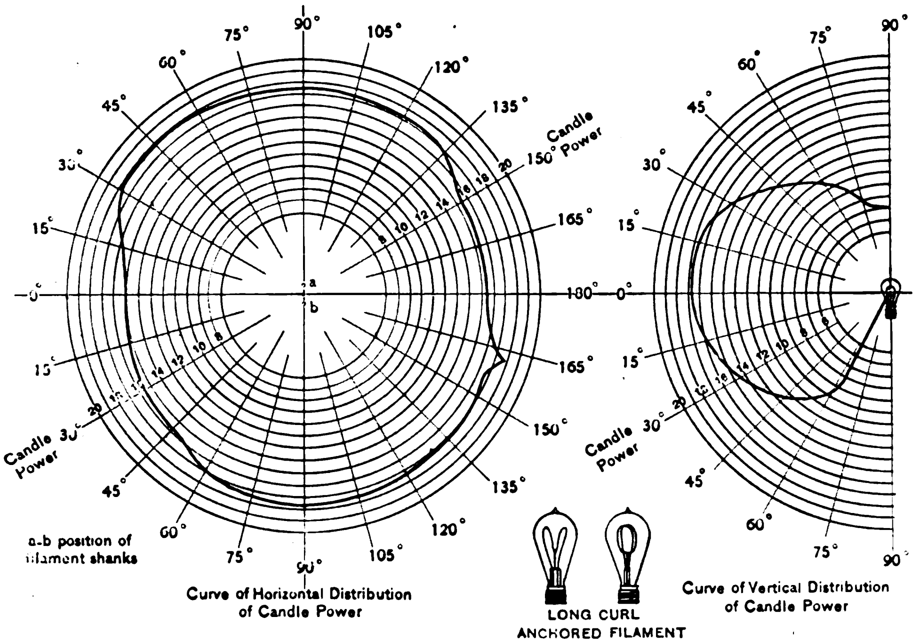


FIG 4.—HORIZONTAL AND VERTICAL DISTRIBUTION WITH OVAL ANCHORED FILAMENT.

It is interesting to notice, in these plots of illumination, that after the 45 degs. ray is passed the value of all types of filaments is about the same; and it should be noted that the illumination procured is very small. An illumination of 1/10 of a candle-foot, for example, is that which one receives on a piece of paper held vertically more than 3 ft. from an ordinary candle. Such light as passes out from a lamp in directions nearly horizontal or above the horizontal plane is useless except it is reflected back to the surfaces to be lighted or contributes to the general illumination by dispelling the gloom of the upper parts of a room and by giving a diffused character to the light.

A number of interesting matters connected with the distribution of light from lamps having filaments of the different types are shown in Figs. 3 to 6, inclusive. Each figure gives the results from a test of one lamp—a lamp chosen to represent the type because it was truly representative mechanically, and by check against other lamps was found to be representative in light distribution. The left-hand lamp sketch shows the lamp as it stood for measuring the horizontal candle-power at 0 deg. and the right-hand figure at 90 degs. In all the candle-power diagrams the distance out radially from the center of the diagram to the heavy curve gives the candle-power in that particular radial direction.

All the lamps were kept at the voltage at which they give 16 candle-power on the basis of the manufacturer's rating. The curves of horizontal distribution show that the candle-power distribution of the long-curl anchored filament and the double filament are somewhat similar. The irregularity of the curves for the single-coil and double-coil lamps filament types is great. This is always distinctive of lamps of the sort.

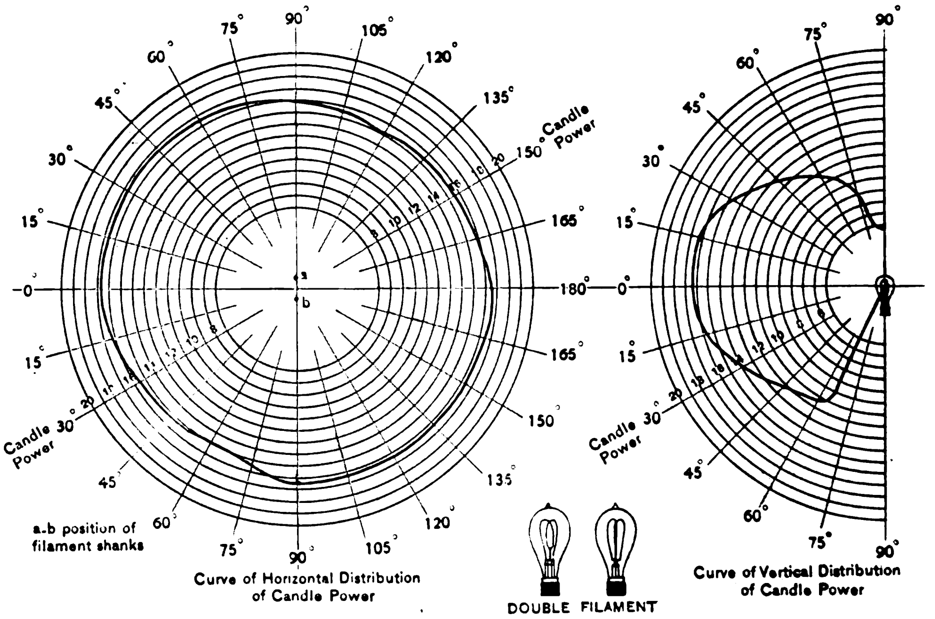


FIG. 5.—HORIZONTAL AND VERTICAL DISTRIBUTION WITH DOUBLE FILAMENT.

It does not take much consideration of these curves to satisfy one that a 16-c.p. lamp is not necessarily one which gives 16 candle-power where this much light is wanted. The candle-power of incandescent lamps is determined really in a very empirical and arbitrary fashion. Most people seem to think it is as surely known as the watts used, and is as readily measured. But really it is about as vague and elusive a value as the candle-power of an arc lamp, for which is has facetiously been said that it gives 2000 candle-power because at any street corner it delivers 500 candle-power in each of the four directions.

The common method of measuring candle-power in use by the manufacturers of incandescent lamps is to spin them at 180 revolutions per minute on a vertical axis and measure the average horizontal candle-power by a single reading.

In Table II I have set down a number of candle-power values for each of the five lamps of which some data was given in Figs. 3 to 6, inclusive. Each of these gives a value of candle-power by which the lamp might be called. The values were procured as follows: A lamp was set at 16 candle-power when rotating at 180 revolutions per minute with the lamp axis vertical, in the common arbitrary method, and for all measurements involved in the other tabulated values was held at that voltage. Values in line b were determined by taking the average of twelve readings as the lamp is turned, beginning with its standard position and at every succeeding 30 degs. Values in line c are computed from the curves in Figs. 4 to 8 which take account of all horizontal candle-power variations. The line of mean spherical candle-powers is computed by the Franklin Institute method.

Line e gives the candle-power these lamps should have been marked if rated by the National Electric Light Association's standard. The readings are not by a rotating socket, but average from readings made individually from the lamps tilted at the right angle. It will be noted that this agrees poorly with the value of mean spherical candle-power and bears no easy numerical relation to it. Line f of the mean hemispherical candle-power is to be compared with the spherical candle-power values, and this in turn with the line g, in which average candle-power is included every ray of really useful light. Line h is set down for comparison and to mention later.

TABLE II.

Candle-Power Taken.	Candle-Power.				
	Single U-shaped Filament.	Single Curl Filament.	Long Curl Anchored Filament.	Double Filament.	Double Coil Filament.
(a) At 180 revs. with axis vertical	16	16	16	16	16
(b) Mean horizontal (standard method)	15.8	16.2	16.6	16.0	15.72
(c) Mean horizontal (from plotted values)	16.0	16.7	16.7	16.1	15.6
(d) Mean spherical (standard method)	12.7	13.5	13.75	13.2	13.8
(e) Mean with axis at 45°	10.5	12 0	11.7	12.0	14.0
(f) Mean hemispherical	14.3	14.5	14.6	14.0	14.5
(g) Mean within 30° from tip	8.7	10.3	8.7	7.9	10.9
(h) From the tip	5.7	8.35	7.05	4.8	10.1

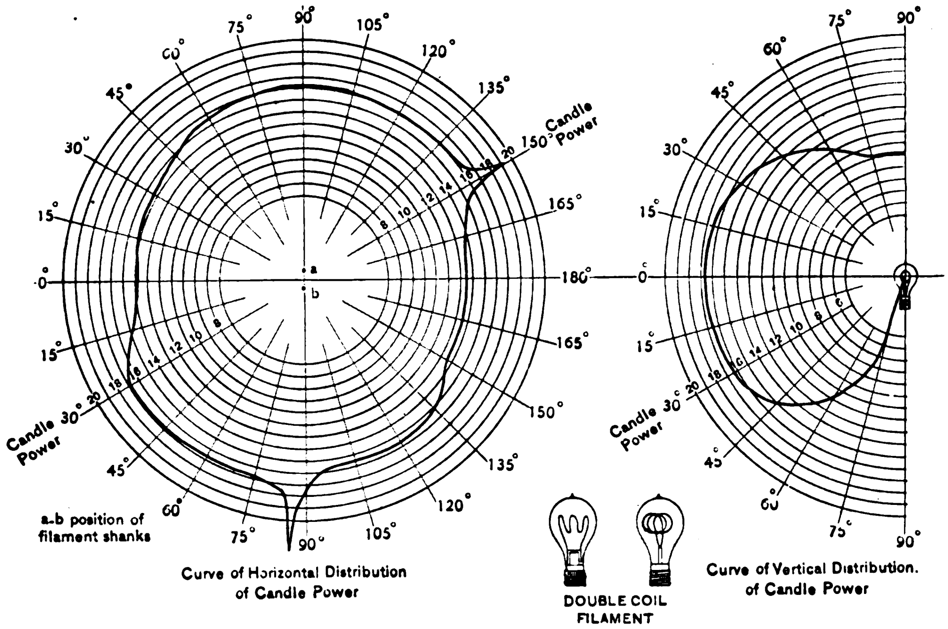


FIG. 6.—HORIZONTAL AND VERTICAL DISTRIBUTION WITH DOUBLE-COIL FILAMENT.

With such an array of candle-power values for each lamp, what is its candle-power? Earlier it has been pretty thoroughly explained that the only sensible candle-power by which to call an incandescent lamp is that which is useful in producing illumination at desired points. Such a method has never been used in marking incandescent lamps for sale.

It has already been explained that mean spherical candle-power is an impossible measurement for commercial purposes. Rotation methods are poor, too. Not only does the speed of rotation affect the result procured, but some of the best modern lamps produce such a flicker at the car of the photometer when rotated at standard speed (180 revolutions) that not only is the making of an observation most trying to the eyes, but the observer can only make a rough guess for the position of his screen when a balance is obtained. A recent suggestion to choose such a speed for each lamp as just removes the flicker is impractical, also; for not only does it require an adjustment of speed with different lamps, but with many filaments high speed of rotation distorts the filament or even throws it against the glass, due to centrifugal forces brought into operation by the high speed.

What more rational, then, than to measure the lamp's candle-power looking in at the end? It is the light coming from the end which we make use of—which we are interested in. Then this is the light to measure, and that by which the lamp should be rated. Lamps measured thus are as comparable with each other as lamps measured any other way. The apparatus required to make the measurement would be very simple, for no rotating device would be required and the lamp need only be inserted in the socket without any care as to which side comes uppermost when its candle-power is determined, since the candle-power must always be read the same. Thus, readings of different observers would agree without respect to anything involved in the measurement, except the standards used and the personal element, which never can be eliminated. Such a radical change of method, however sensible the change, could not be made without the sanction and support of some of the large associations of electrical engineers. In the meantime, however, for eventually this method must certainly come to be used, all lamp users should, in addition to a measurement of candle-power in the conventional way to check up the lamps purchased, take a reading of the useful light out from the tip.

A 16-c.p. lamp should be one giving 16 candle-power from the tipped end. The horizontal candle-power might be considerably less and be irregular in different directions without altering the real value of the lamp. An ideal 16-c.p. lamp would perhaps be one which measured 16 candle-power from the tipped end, had 16 candle-power as the mean horizontal candle-power, and was of nearly 16 candle-power mean spherical. Such a lamp could be turned into any position in an electrolier and still give an illumination as good as before and as well distributed.

So far no word as to the efficiency of lamps has been said. All the lamps mentioned above were 3.5-watt 16-c.p. lamps, by the conventional method of measurement. But the efficiency or watts per candle-power is strikingly varied by the candle-power to which reference is made. In Table III are set down the efficiencies of each lamp of the five types, calculated on the basis of the candle-power values in Table II. A 3.5-watt lamp turns out to be one which uses this much electric power per candle-power if this is reckoned at its highest value, the mean horizontal. What a terrible inefficiency these lamps have if we calculate the watts per candle-power from the useful light or the light from their tips!

TABLE III.

Watts Based on Candle-Power, as Stated.	Watts per Candle-Power.				
	Single U-shaped Filament.	Single Coil Filament.	Long Curl Anchored Filament.	Double Filament.	Double Coil Filament.
(k) At 180 revs with axis vertical	3.5	3.5	3.5	3 5	3.5
(l) Mean horizontal (standard method)	3.54	3.45	3.37	3.50	3.56
(m) Mean with axis at 45°	5.53	4.66	4.79	4 66	4.00
(n) Mean spherical	4.40	4.15	4.07	4.23	4.07
(o) Mean hemispherical	3.92	3.86	3.83	4.00	3 86
(p) Mean within 30° of tip	6.44	5 44	6.44	7.09	5.14
(q) From the tip	9.82	6.71	7.95	11.70	5.54

Lines p and q of Table III give this. The single-coil and double-coil filaments are the only ones whose efficiency reckoned in a rational way is at all reasonable. All of the lamps were supposed to have the same average life and would not be very far different in maintenance of candle-power during life. If a lamp can be made which gives 16 candle-power out from the tip and burns at 5 watts per candle-power, we will have a lamp which is better than any now made.

The foregoing is an abstract of a paper read before the Franklin Institute, Philadelphia, at its stated meeting, held September 19.

Abstracts from Foreign Contemporaries

Measuring Instruments for Railways.—In a recent issue of the "Elektrotechnische Zeitschrift" Gisbert Kapp describes a simple and interesting instrument for measuring the tractive force on electric railways. In a railway car a tube is placed parallel to the rails, to its ends two vertical glass tubes are connected; the tubes are filled with water. The points to which the water reaches in the vertical tubes while the car is at rest on a horizontal road, are marked zero. If the car rests on a grade, the main tube being still parallel to the rails, and the two end tubes being perpendicular to them, the water will rise in one tube and fall in the other, and this rise and fall indicates the degree of the grade; it indicates also the gravity component parallel to the road. If the car is running with varying speed on a level road, the acceleration produces a difference of height of the water in the two end tubes, and this difference of height indicates the tractive force required for acceleration. Therefore, in the general case of a car running with varying speed on a grade, the instrument indicates at once the tractive force required for climbing up against gravity, together with that required for acceleration, in pounds per ton of rolling weight. This is illustrated in Fig. 1, where the line, a b, represents the axis of the main tube parallel to the rails, and the lines, a c and b d, the axes of the end tubes. If the water in the tubes extends to the points, F and B, the difference of height, A F, indicates the whole tractive force, A C being the part due to the inclination and C F being due to acceleration. A practical form of the instrument is shown in Fig. 2.

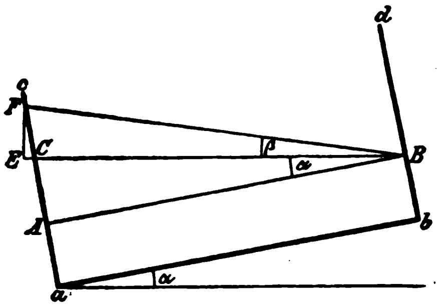


FIG. 1.

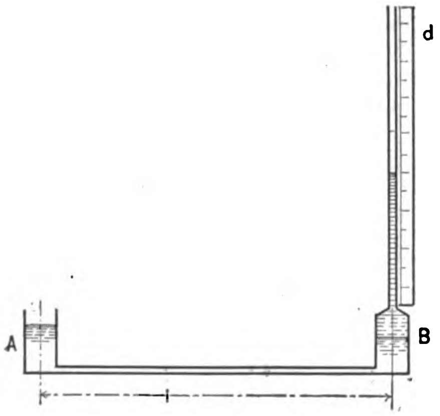


FIG. 2.

Starting Three-Phase Induction Motors.—Three-phase induction motors exhibited at the Paris Exposition by the firm of Krizik, Prague, an interesting starting device of Mr. Fischer-Hinnen is used, which is described in several French periodicals. The motor is started with high resistance in the secondary in the ordinary way, and this resistance is cut out automatically with increasing speed. This is accomplished in a very simple manner by shunting the starting resistance with an induction coil of very high inductance and very small ohmic resistance, as shown diagrammatically by Fig. 3, where R is the starting resistance, and X the induction coil. The reactance of this induction coil is proportional to the frequency of the e.m.f. in the secondary circuit; this frequently is, of course, proportional to the slip and decreases therefore from maximum at standstill to nearly zero when the motor speed is near synchronism. Consequently, the reactance of the induction coil, X, decreases as the speed increases, so that at full speed it forms practically a short-circuit to the resistance, R. Fig. 4 shows the arrangement for a three-phase induction motor, with collector rings for connecting the induced secondary circuits to the starting resistances and reactances in parallel. As this starting device occupies only a small space, it may be placed in the rotor and the collector rings eliminated.

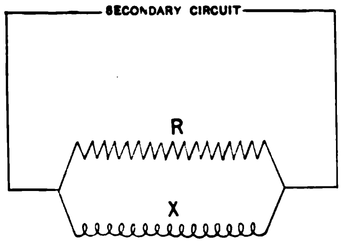


FIG. 3.

Regulating Device for Step-by-Step Resistances.—In a recent number of the "Elektrotechnische Rundschau," an interesting device of Schuckert & Co. is described for a step-by-step resistance. As shown in Fig. 5, there are two sets of resistances, W_1 and W_2. Each part of W_1 is equal to the whole resistance W_2; d_1 to d_8, and k_1 to k_7 are contact blocks; c_1, c_2, c_3 are curved metallic strips; b_1, b_2, b_3, are sliding shoes for connecting the buttons with the curved strips. The shoes, b_1 and b_2, are insulated from each other, but fixed on the same arm, which is pivoted at a_2; b_3 is carried by an arm pivoted at a_1. The two spindles, a_1 and a_2, are connected by a suitable gearing, so that the arm on a_2 turns from one contact block to the next, say from d_6 to d_7, while the arm on a_1 makes a full revolution. In the position illustrated in Fig. 5, W_1 and W_2 are connected in series; by turning the arm on a_1 the sections of the resistance, W_2, are successively cut out. When this arm has completed a full revolution, so that the sliding contact, b_3, occupies again the position illustrated in the diagram, then the contact, b_1, connects d_6 and c_1, and the contact, b_2, connects d_7 and c_2; then the whole resistance, W_2, is connected in parallel with that part of W_1 which is between the contacts d_6 and d_7. Another revolution cuts out the first section of W_1, and so on.

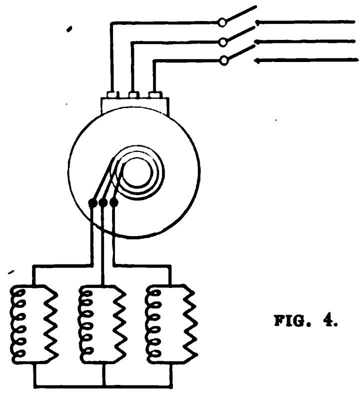
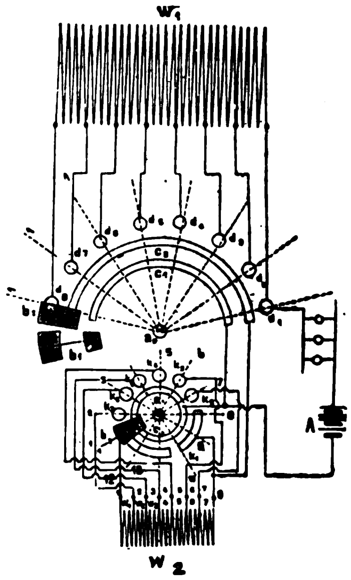


FIG. 4.



FIG, 5.

Holden Energy Meter.—In the Paris Exposition the Holden energy meter attracts some attention. The following description of same is taken from an article by Mr. Garfield in a recent issue of "L'Industrie Electrique." Its construction is shown in Figs. 6 and 7. The instrument consists essentially of two parts. The upper part is a wattmeter of the electrodynamometer type; its series coils, C, are fixed, while the shunt coils, D, can turn around the vertical spindle, B, against the action of the springs, F, the angle of deflection being limited by the pins, d. This deflection is transmitted to the lower part of the instrument, which thus receives from the upper part a certain amount of kinetic energy; this lower part of the instrument rotates around the vertical spindle, B^1, until its kinetic energy is consumed by the damping action of the metallic disc, K, which rotates between the poles of a permanent magnet. The instrument is so made that the angle of rotation of the lower part of the instrument is proportional to the power in the circuit at the moment when the wattmeter was connected to it. It is evident that when the wheelwork driven by a screw at the lower end of the spindle, B^1 sums up all angles of rotation of this axle, the total energy is registered. The spindle, B^1, carries besides the disc, K, three horizontal arms provided with weights and bearing a ratchet wheel; by means of a pawl attached to the lower end of the spindle, B, and acting upon the ratchet wheel, the spindle, B^1, receives a rotatory impulse every time the shunt coils of the wattmeter are deflected. The shunt coils are connected to the circuit periodically by clockwork.

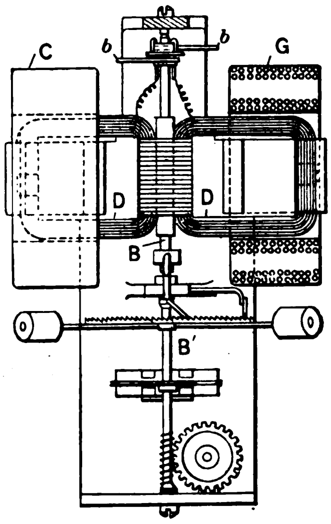


FIG. 6.

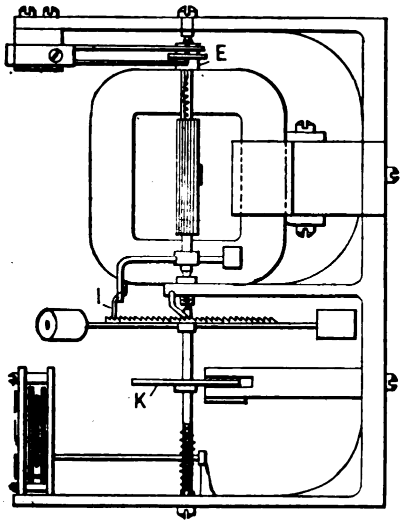


FIG. 7.

Slaby-Arco System of Wireless Telegraphy.—A recent issue of the London "Electrical Review" has a description of this system which has been adopted by the German navy, not on account of superiority in respect of the distances over which messages can be safely sent (25 to 28 miles over sea, with vertical wires 38 to 44 yards high), but on account of its practical serviceability, prevention of danger from high pressures, avoidance of difficulties of insulation in the transmitter, and of atmospheric disturbances in the receiver, together with a greater solidity and simpler manipulation of the whole system. While it is based on the same principle as the Marconi system, it differs from that system in some important points. The arrangement of the transmitter is illustrated in Fig. 9, and that of the receiver in Fig. 8. The vertical wires of both the transmitter and the receiver are connected to earth. In the transmitter the secondaries of the induction coil, J, are connected to a condenser, C, which discharges on one side through the spark gap, F, and on the other side through E_2, direct to earth; S is an aerial wire netting. In Fig. 8, S is the aerial wire netting; F, the coherer; R, a Morse relay, and B the battery. When ether waves arrive at the coherer, its initial high resistance is reduced and the battery current goes through the relay, the aerial wire and earth. In previous arrangements the waves which reached the coherer were shunted by the local circuit and their effect was thereby weakened, but in the present system the series arrangement adopted completely removes this defect; atmospheric influences are also greatly diminished by the series arrangement. Instead of a simple aerial wire, an earthed wire cage or netting may be used. An automatic interruption of the coherer circuit is provided, so that the blow of the tapper is only given to the coherer tube after the tension of the coherer elements is taken off; by this means not only is easy and satisfactory coherence effected, but the life of the coherer is said to be considerably prolonged, since the sparking which would otherwise occur in the interior, and would gradually destroy the coherer powder, is to take place externally.

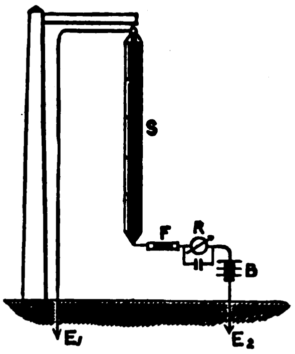


FIG. 8.

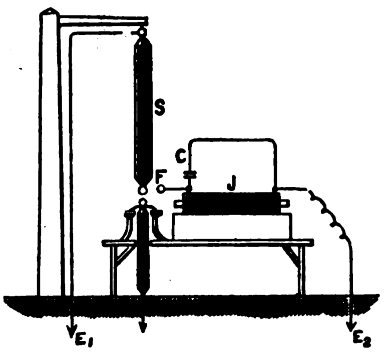


FIG. 9.

Some Recent Electrical Patents

Lightning Arrester.—A patent has been issued to W. E. Athearn for a lightning arrester which combines a spark gap and an impedance coil, and also constitutes a fuse-holder. This arrangement is illustrated in Fig. 1, which is almost self-explanatory. The binding posts, p and p, constitute the terminals of the device, and the ground wire is attached at g. The fuses are attached between the posts, p and b, and the coil, i i, supplies the choking effect intended to divert the lightning discharge to the ground plate, m, which is adjusted in close proximity to the convolutions of the coil. Patent No. 656,780.

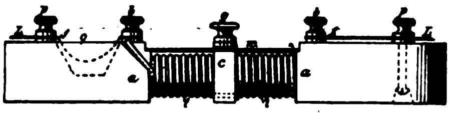


FIG. 1.

Commutator Construction—One of the most difficult features involved in the construction of large dynamos is the arrangement of the commutator bars so that the brush treated will remain a true circle. In order to obtain this condition the construction of the commutator must be such that none of the segments or bars can possibly work loose. With a view to securing this result J. T. H. Dempster has resorted to the use of a circular key which is divided into segments for greater conven-

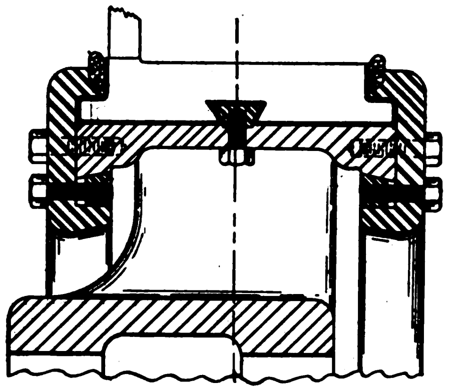


FIG. 2.

ience in assembling and which passes transversely through a dove-tailed groove in the under edges of the commutator segments, as shown in Fig. 2. In assembling the commutator, the circular keys, with the exception of one section, is set loosely in place on the rim of the spider, with the commutator bars are threaded on. When all the commutator bars are in place except those belonging to the section of the circular key which was omitted, the remaining bars are threaded on this section and it is drawn solidly into place along with those previously set on the spider rim. The heavy black line in the engraving indicate the usual mica or similar insulation. It is obvious that the construction also facilitates the removal of one portion of the commutator without disturbing the remainder, which is of course impossible with ordinary construction. Patent No. 656,177.

Arc Lamp Carbon Feed.—A patent has been issued to T. E. Drohan for a remarkably simple and rather ingenious carbon clutch adapted to the "concentric-mechanism" type of arc lamp. The patent illustration is shown by Fig. 3, in which C is a tube slightly larger in bore than the diameter of the carbon and secured at its upper end to the plunger of the regulating solenoid; the lower end of the tube carries the clutch frame, d, to which is pivoted a bifurcated lever, h. Between the two arms of this lever is mounted the clutch roller, g, in such a manner that it can move toward or away from the carbon, as indicated in the right-hand sketch, the axle of the roller being supported in slots, m. The operation of the clutch is obvious. When the solenoid core draws the tube, C, upward the roller crowds the carbon against the side of the tube so that the two move together and the arc is struck. As the arc burns away the solenoid falls gradually in the usual manner until the end of the clutch lever, h, strikes the tripping post, k, which relieves the pressure of the roller against the carbon and the latter is allowed to feed down. Patent No. 657,485.

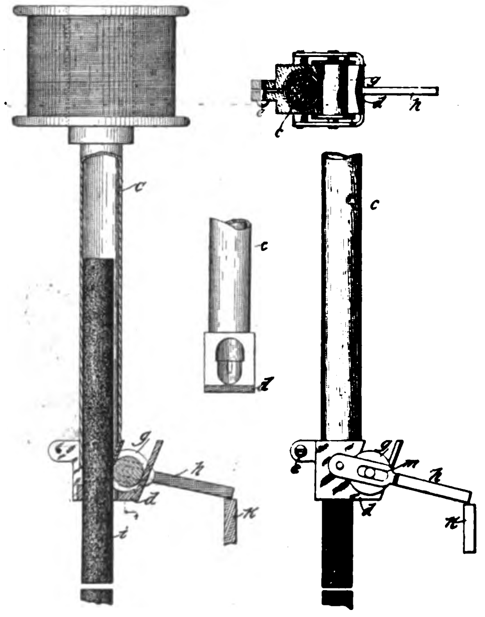


FIG. 3.

Combined Arc and Nernst Lamp.—An ingenious form of lamp in which is combined both arc and incandescent illumination has been patented in this country by Prof. J. A. Fleming, of London. The seat of illumination, as shown in Fig. 4, consists of two electric-light carbons, *a* and *d*, of oblong cross-section, the upper of which has two holes, *b*, *b*, cored in it. Into these holes are placed pencils, *c*, *c*, of refractory oxid, such as magnesia. The upper carbon is fed in the ordinary manner by an arc lamp mechanism. When the arc is struck, the two cores of refractory oxid, which fit loosely in the upper carbon, rest on the lower carbon and ultimately become heated by the arc until they pass sufficient current to become brilliantly incandescent, adding their illumination to that of the arc itself, which continues to be maintained between the ends of the carbons. Patent No. 653,572.

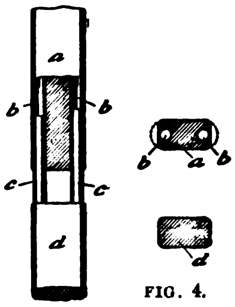


FIG. 4.

Heater Out-Out for Nernst Lamps.—It is well known that Nernst lamps require a heating device to bring the refractory material up to a conducting temperature, and various means have been devised for throwing the heating device out of circuit as soon as the illuminating rod becomes a conductor. One of the simplest and most obvious of these has been patented by Mr. Henry N. Potter and assigned to Mr. Geo. Westinghouse. This device is illustrated by Fig. 5 and consists simply of an electromagnet connected in series with the glower and arranged so that as soon as current flows through the glower the magnet lifts its armature and opens the circuit through the heater, *H*. In the diagram, *A* is the illuminating rod; *B* is a steadying resistance, and *H* is the heater. Patent No. 652,639.

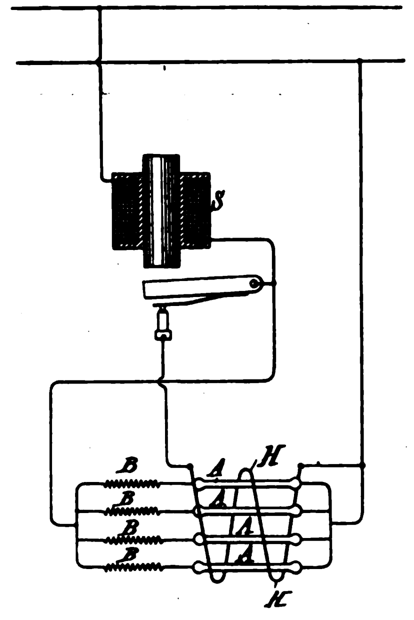


FIG. 5.

NEW BOOKS.

A Hand-Book of the Electro-Magnetic Telegraph. By A. E. Loring. New York: D. Van Nostrand Company. Linen-covered boards; 116 pages, 4 x 6 ins.; 24 illustrations. Price, 50 cents.

This is the fourth edition of Mr. Loring's admirable little work, in which he has added a chapter on the duplex and quadruplex systems. Only the Stearns and polar duplex systems and the combination of these into the old Western Union quadruplex are considered, which is regrettable. A description of the modern quadruplex systems would have added immensely to the value of the book. As it is, however, no telegrapher with a mite of ambition can afford to do without this manual at the nominal price asked for it.

American Telephone Practice. By Kempster B. Miller. New York: American Electrician Publishing Company. Cloth; 518 pages; 6½ x 10 ins.; 379 illustrations. Price, $3.

This is the third edition of this work, which has been enlarged, both as to size and number of pages, and completely revised. The chapter on primary batteries has been extended and the remarks on storage batteries have been expanded into a distinct chapter on this subject. A chapter on Automatic Exchanges and one on Specifications have been added, and all of the chapters containing descriptive matter have been revised to include the latest current practice.

NOTES.

Electrical Apparatus Wanted in Brazil.—Dr. Olympio DeAssis, of Minas, Brazil, writes that some electric railway lines will be built in his town, and he requests manufacturers of electrical apparatus and all kinds of street railway equipment to send him catalogues, price-lists, and any other information which will be of use in this connection.

The Twenty-First Edison Convention.—The Association of Edison Illuminating Companies held its twenty-first convention at Saratoga Springs, N. Y., September 4th, 5th and 6th. The convention was pronounced emphatically a complete success. The papers which were read were exceedingly valuable and it is greatly to be regretted, so far as the general electrical fraternity is concerned, that the Association will not allow these papers to be made public.

Rapid Transit in Europe—Mr. H. C. Du Val, who has just returned from Europe, does not speak encouragingly of the underground rapid-transit systems in London and Paris. Both of these systems enforce the rule that no passengers will be allowed on a car after it is filled and as a result many Americans, after making a few attempts to use the underground systems, gave it up and patronized the surface lines. Mr. Du Val states that there are sometimes 1,000 persons on a station waiting for a chance to get on a car.

Power Plant Economy.—A practical illustration of the economy obtainable in large power stations as compared with small ones is afforded by the Central Avenue power house of the Metropolitan Street Railway Company, Kansas City. This is a compound-condensing plant located on the Kaw River, and operating large direct-connected units. The cost of power in this plant for the first seven months of 1900 was 0.4117 cent per kilowatt-hour including everything except taxes and interest on the investment. This is less than half of the cost of generation shown by any other station in the city.

A Novel Expedient. — During the coming winter the Kansas City Electric Light Company will adopt a rather unusual expedient, namely, the use of rotary converters as alternating-current generators. Two 200-kilowatt rotaries will be put in the west side station where a 500-h.p. Corliss engine is now lying idle, and will be driven by this engine. These will feed step-up transformers with current at 84 volts, which will be raised to 6000 in the secondary for transmission to a new substation at Thirteenth Street and Grand Avenue. There step-down transformers will reduce to 84 volts to supply rotary converters, these rotaries feeding direct-current three-wire mains at 140 volts on a side. When this temporary arrangement is no longer necessary and the company completes its new polyphase distribution the rotaries which have served as dynamos will be put to their orthodox use at some sub-station.

Electrically Operated Railway Switches and Signals.—A large interlocking railroad switch and signal plant, to be located at Sixteenth and Clark Streets, Chicago, will use electric motors and solenoids for the operation of all switches and signals. For working the semaphore signals an electric motor of 1/6 horse-power is to be used. The switches are thrown by a 1-h.p. motor, and the dwarf switch signals are worked by solenoids. On the interlocking machine a "back indication" is furnished by solenoids so that no movement of a lever in the machine can be completed until the operation corresponding to it has actually been completed on the switches or signals A 60-volt storage battery furnishes current, and this is to be charged by a dynamo driven by a gasoline engine, unless other current-supply is available. The system is one recently perfected by the Taylor Signal Company. It is said to be cheaper in first cost, and when properly installed less liable to interference by bad weather than a mechanical or electro-pneumatic interlocking plant.

Tesla Patents Sustained.—The suit of the Westinghouse Electric & Manufacturing Company against the New England Granite Company upon an infringement of the three Tesla polyphase power-transmission patents issued May 1, 1888, was recently decided in favor of the Westinghouse Company. The decision is a very sweeping one and is phrased in part in vigorous verbiage. Other parts of the decision appear unnecessarily oratorical; a notable paragraph of this character reads as follows: "It remained to the genius of Tesla to capture the unruly, unrestrained and hitherto opposing elements in the field of nature and art and to harness them to draw the machines of man. It was he who first showed how to transform the toy of Arago into an engine of power; the 'laboratory experiment' of Baily into a practically successful motor; the indicator into a driver; he first conceived the idea that the very impediments of reversal in direction, the contradictions of alternations might be transformed into power-producing rotations, a whirling field of force."

A Peculiar Chain of Accidents.—In Bateyville, La., a universal mercantile emporium owned by Mr. A. Gautreaux is provided with a telephone and a shot-gun. Ordinarily, there is no connection between the two—at least there wasn't until recently when a thunderstorm arose and a lightning discharge gained more or less forcible access to the gun by way of the telephone equipment. Both gun barrels were discharged, and two charges of heavy buckshot flew wildly through the side of the house, narrowly missing a group of men who had assembled under the lee of the building for shelter. Mr. Prudent Ayre, whose parents obviously named him too soon, was engaged in the time-honored vocation of sawing wood hard by, and was so startled by the sound of the explosion that he leaned for support upon the business edge of a revolving circular saw, which proved itself unworthy of his confidence. The net results of the accidents are an unsymmetrical protrusion of old horse-blanket through the side of Mr. Gautreaux's house and a sad curtailment of Mr. Ayre's reckoning resources.

A Thinly-Spread Honor.—The Director of Liberal Arts and Chemical Industries of the Paris Exposition has addressed the following circular letter to the American journals which were exhibited at the Exposition: "I have the honor to inform you that in accordance with the official announcement of awards at the Paris Exposition of 1900, a grand prize was bestowed upon the exhibit of United States journals, publications and periodicals, and that you are therefore entitled to use this award of grand prize." As there were about 200 American journals exhibited it becomes a matter of some anxiety as to what disposition will be made of the one "grand prize" awarded to all of them. Will it be passed around from office to office for inspection and admiration, and if so what will be the limit of detention in any one office? Will the order of visitation be determined alphabetically, by classes, or how? Before spending sleepless nights over these questions, however, it may be pertinent to inquire just what the outward and visible form of the "grand prize" is, what it is, when it will be forwarded to this country, and who will be the dazzled custodian upon its arrival? About the only serious reference appropriate to this ridiculous award is the comment which was made by one of the New York dailies to the effect that only the most insignificant class of publications would care to lay claim to the empty honor so indiscriminately conferred.

American Street Railway Association.—The nineteenth convention of the American Street Railway Association will be held at Kansas City, Mo., October 16th to 19th inclusive. The programme includes some papers on extremely practical and interesting subjects, among which are "A Comparison of the Various Systems of Electrical Distribution for Street Railways," by C. F. Bancroft, electrical engineer, Massachusetts Electric Companies, Boston; "The Store Room and Store-Room Accounts," by N. S. Hill, Jr., general manager, Charleston Consolidated Railway, Gas & Electric Company, Charleston, S. C., and "Double-Truck Cars; How to Equip Them to Obtain Maximum Efficiency Under Varying Conditions," by N. H. Heft, president, Meriden Street Railway Company, Meriden, Conn. An exhibition of street railway apparatus and supplies will be made in connection with the convention and the final day of the meeting has been set aside for the inspection of the exhibits. The exhibits will be shown at Convention Hall, which is one of the largest open halls in the country and excellently adapted for this purpose. The usual annual banquet will be held on the evening of the final day, when the newly elected officers of the association will be installed.

The New York Committee on Transportation, consisting of Messrs. H. H. Vreeland, James H. McGraw, Chas. W. Price and T. C. Martin, has arranged with the New York Central & Hudson River R. R. for a convention train to leave New York at 10 o'clock Sunday morning, October 14, arriving at Kansas City at 9:30 the following night. This train will leave other cities en route as follows:

Leaves Poughkeepsie 11:45 a. m., Sunday, October 14; Albany, 1:30 p. m.; Schenectady, 2 p. m.; Utica, 3:40 p. m.; Syracuse, 5:05 p. m.; Rochester, 6:50 p. m.; Buffalo, 7:40 p. m. (central time); Erie, 9:40 p. m.; Cleveland, 12:10 a. m., Monday, October 15th; Indianapolis, 8 a. m.; St. Louis, 2:15 p. m.; arrives Kansas City, 9:30 p. m.

The train will consist of baggage, smoking and Pullman vestibuled drawing room sleeping cars, and a dining car serving meals through to Kansas City. A special representative of the New York Central will accompany the party to Kansas City. A special rate of one and one-third fare on the certificate plan has been obtained, and delegates when purchasing tickets should ask the ticket agent for a certificate which on presentation at Kansas City will secure a reduction of two-thirds fare for the return trip. The single trip fare from New York is $31.75; sleeping car accommodations are at regular rates.

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In requesting your address changed give OLD as well as new address.

NOTICE TO ADVERTISERS.

Changes in advertisements should reach the office of the American Electrician by the 15th of each month in order to appear in the following issue. New advertisements can be received up to the 25th of each month.

IMPORTANT NOTICE.

Intending subscribers are warned not to place subscription orders with persons who cannot show written authority to take such subscriptions and make collections therefor, as the paper will not undertake to fill orders placed with alleged agents acting without such written authority.

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Industrial Electricity in the West.

The chief differences between electrical work of one part of the country and that in another are those due to different commercial or physical conditions, though the conservatism of the east and the rather bold progressiveness of the west naturally exert antipodal influences upon the achievements in actual practice in these respective sections. Probably the most striking thing to an eastern electrical man going through the central states from Pittsburg to the Missouri river is the foothold gained by the independent telephone movement, along with which has come an extended use of country toll lines and farmers' telephones. The causes of this development are too numerous to discuss here, but the simple fact is notable.

The tendency toward consolidation of electric railway and lighting interests in these same central states is not so great as in eastern communities, where often a number of good-sized towns are closely grouped. To be sure, consolidations have been as readily brought about in the west as in the east when the local conditions invited it, but as a rule cities and towns are too far apart to make interurban railway networks or consolidation of neighboring village lighting plants practical. The central west is also pre-eminently the land of the small electric light station—a fact illustrative of the enterprise and prosperity of many of the small western towns, backed as they are by steadily and richly productive farming districts.

Going farther west to the Rocky mountains and beyond, an entirely new set of conditions is found. Some of the far western cities were among the first to adopt electricity for lighting and power, and railway and lighting plants have sprung up wherever the population justified it (and some places where it did not), these plants being run by steam power in spite of high cost of fuel in some cases. The past five years, however, have shown great activity in the development of western mountain water powers and the transmission of power over long distances. The high price of fuel, of course, is a strong incentive to investment in transmission plants of this kind, while mountain waterfalls with their high heads are comparatively reliable and easy of development, considering the amount of power usually available.

Another class of electrical work in the mountainous regions about which little has been said but the importance of which is beginning to be recognized, is power transmission from waterfalls to mines. Lucrative mineral lodes have an inconsiderate habit of locating themselves in most inaccessible districts and where coal beds are unknown. In many such cases electrical transmission between some nearby waterfall and the mines would effect a saving in the handling of a low-grade ore sufficient to turn a losing mine into a paying one. As a consequence it is now often the case that in the development of a mining property an electric transmission plant to furnish cheap power is included in estimating the outlay, as being just as logically a part of the equipment as stamps or concentrators or dredges.

◆

Enclosed Arc Lamps on Series Circuits.

The contention has frequently been made—just on what grounds was never made clear—that the benefit of enclosing the arc of a direct-current lamp was out of the reach of the poor, unfortunate mortals who operate series circuits from arc dynamos. There was some mysterious reason why direct-current enclosed arcs on series circuits were impractical, although hundreds of alternating-current arcs are working in that manner every night. Of course, such an argument cannot be sustained by any sound engineering considerations, and probably no one has deemed a logical controversion worth the trouble when confronted with this wholly arbitrary statement. That none is necessary is fully demonstrated by the operation of the municipal plant at Grand Rapids, which is described in another part of this paper.

The tests of the Grand Rapids plant show the interesting economy of 1 1/3 lamps per horse-power indicated in the engine cylinders—not delivered to the dynamo pulley. This is not as good as a modern constant-potential generator would show, driven by the same engine, but it is sufficiently high to justify a careful comparison of the two systems in laying out an arc-lighting plant. On the one hand, the direct-current apparatus is simple in the extreme, has a power factor of unity and is cheaper to install; on the other the constant-potential system is more efficient, more economical in floor-space—one generator type serving all needs—and more flexible. But it has a low power factor and necessitates either a multiplicity of circuits or the use of cumbersome station transformers. In the latter case the efficiency falls nearly to a level with that of the direct-current enclosed-arc system.

Uninformed Ambition.

At more or less frequent intervals one's commiseration is aroused by a report to the effect that some poor fellow, usually in a benighted locality and always in that condition of mind, has made a marvelous invention which is going to revolutionize the present crude blunderings of the less original masses of theory-ridden engineers. While the arbitrary obtuseness and pertinacity of the "inventor" nearly always mitigate the sympathy of his better-versed audience, there is still left a moiety of compassion—wholly undesired and unappreciated by its inspirer—for the evident lack of matriculation which fetters a commendable ambition. It seems rather surprising that an absolute ignorance of fundamental laws, to say nothing of the state of the abused art, should prevail to the extent that it does among persons obviously and deeply interested in electrical or mechanical matters. The existence of a profuse amount of didactic engineering literature couched in plain language renders it unnecessary that any-one of ordinary intellect and having the ability to read should remain crassly ignorant on the more commonplace features of any branch in which he may be interested.

A recent case of the sort under discussion is that of a young man in a western city—not a village—who has "invented" the use of permanent magnets for dynamos and motors! And the deluded soul is inflated by rose-colored visions of pecuniary emolument conjured up in a flamboyant daily newspaper article scare-headed: "Fabulous Fortune in Sight!" The article is typical of the utter recklessness which usually characterizes the pseudo-technical utterances of the lay press. It is stated that "never before have permanent magnets been used" as field magnets for dynamos or motors, and that the brilliant application of them in this case has resulted in a motor so powerful that the current from an ordinary incandescent lighting circuit has to be greatly reduced by a water resistance to keep the speed within bounds. The "technical" points of the article were supplied by the inventor (who is in the piano business) while the newspaper contributed the sensational features.

If the inventor had been a reader of any electrical journal, or had asked the advice of the editor of any such publication before wasting time and money on an ancient and obsolete idea, he would have missed a good deal of transient local glory, but his usefulness to himself as well as to his community at large during the fool's paradise period would have been several points higher than it could possibly have been under the actual conditions. Moreover, he would have been saved the chagrin and "pecuniary remorse" incident to the cruel awakening which inevitably awaits him.

The Rating of Incandescent Lamps.

The determination of mean candle-power from zonal distribution is an extremely intricate process requiring the utmost accuracy while involving a delicacy of adjustment that militates irritatingly against that accuracy. It is largely on this account, doubtless, that mean spherical or hemispherical candle-power has not been made the standard of measurement for incandescent lamps. As most of our readers know, the prevailing standard is the average horizontal candle-power given by a lamp while rotating at 180 r.p.m. about a vertical axis represented by a geometrical line from the tip through the center of the base. In a paper read before the Franklin Institute recently, an abstract of which appears elsewhere in this issue, Prof. A. J. Rowland advanced the rather radical argument that candle-power measurements should be taken with the tip of the lamp pointing toward the photometer —that is, with its normal vertical and horizontal axes transposed—in support of which argument he contends that (1) nearly all lamps are mounted tip downward, and (2) no light rays making an angle greater than 45° with the vertical need be considered.

It will, of course, be conceded that most lamps are mounted with the tips pointing more or less below the horizontal, if one ignores the comparatively small proportions of lamps used for desk and other special illumination. But in order to afford any real justification of Prof. Rowland's suggested standard of measurement (from his own standpoint as to the most valuable light rays), the vast majority of lamps used for general illumination would need to be mounted in a perfectly vertical position, and this condition, of course, does not hold good except in country towns and very small cities where electroliers and brackets are contemplated from an economical distance, with awe and vague admiration. Assuming for the moment that most lamps hang vertically, the advocacy of taking 45° from the vertical as the standard criterion of usefulness, and making the candle-power given through the tip the standard measurement, leads directly to the great drawback which is chiefly accountable for the rise of the alternating-current arc lamp and the decline of the more efficient direct-current arc—namely, intense illumination approximately in line with the lamp axis and poor distribution elsewhere. The experience of arc lighting stations is ample evidence that this is not desirable.

As a peculiar matter of fact, however, Prof. Rowland's argument for "end-on" measurement is more nearly justified by the methods of mounting incandescent lamps actually prevailing than by the condition which he erroneously assumes. A tremendous majority of lamps are disposed with the tips pointing anywhere from horizontally to an angle of 60° below the horizontal, and in these two positions, or any intermediate one, a large proportion of light would be wasted without reflectors because the strongest light is perpendicular to the lamp axis and half of these rays are projected above the horizontal. For lamps thus mounted, the greatest illuminative efficiency would undoubtedly be obtained with the maximum candle-power coming through the tip, but it would manifestly be necessary that the mean horizontal candle-power of the lamps be pretty high in order to avoid imperfect surface distribution immediately under the lamps.

The "end-on" measurement would provide one greatly desirable feature, namely, the photometric measurement of lamps held stationary instead of revolving. With a filament anywhere near symmetrical in shape and mounting, it would make no photometric difference practically whether the socket were rotated or stationary so long as the longitudinal axis would be kept in line with the photometer. Obviously this would be a tremendous relief to those making the measurements and would conduce to greater accuracy of observation; but this is only one consideration, and so far as the ultimate user of lamps is concerned it does not enter. What he wants is as nearly uniform distribution as possible, and in order to obtain this reflectors are indispensable, no matter in what direction the maximum candle-power is given out. In view of this fact and the additional fact that in practice lamps are mounted in every conceivable position, the suggested method of measurement does not appear to offer sufficient advantage to justify the revolution in methods of manufacture which its adoption would involve.

DESIGN FOR A ½-H.P. SINGLE-PHASE INDUCTION MOTOR.

BY J. C. BROCKSMITH, M. E.

The development, during the past ten or twelve years, of polyphase induction motors and the experience gained in their construction and operation has made possible a single-phase motor constructed along similar lines and possessing many of the desirable features of polyphase motors.

The induction motor is virtually a transformer in which the primary and secondary windings are movable with respect to each other. The primary is usually made the stationary member or stator of the machine, and the secondary the revolving member or rotor. When in normal operation the magnetic field of an induction motor is of practically constant strength and revolves with the frequency of the supply circuit when of two poles, and when more than two poles are used the rotation is inversely as the number of poles.

The rotor of an induction motor will take up a speed which is always less than the speed of field rotation by an amount which is called the "slip" and is expressed as a fractional part of the synchronous speed.

In making the necessary computations for a motor the speed of rotation must first be settled upon. This may profitably be chosen as high as possible if, as in the present case, the motor is to operate on the higher frequencies of 125 to 140 cycles per second. For the motor here described four poles were adopted, giving a synchronous speed of 3750 r.p.m. at 125 cycles, and a speed at full load of 10 to 15 per cent less, or about 3300 r.p.m. By making certain changes, which will be explained later, the motor may be operated at practically the same speed and output on 60 cycles.

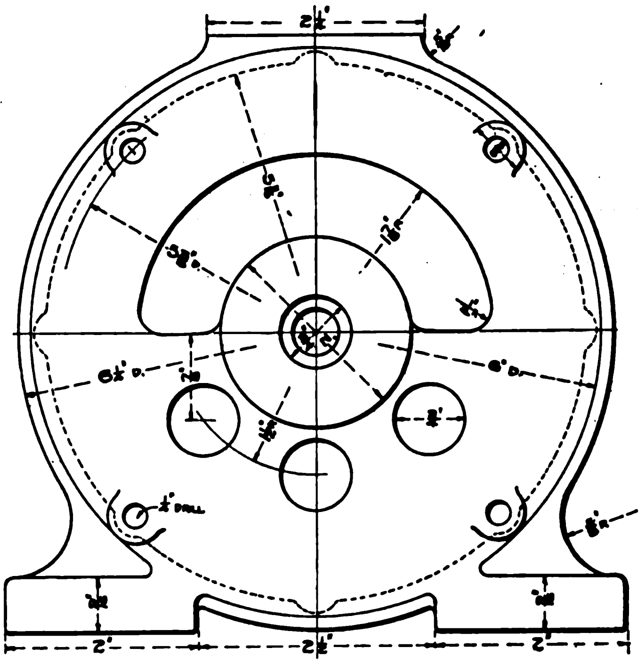


FIG. 3.—END PLATE OF MOTOR.

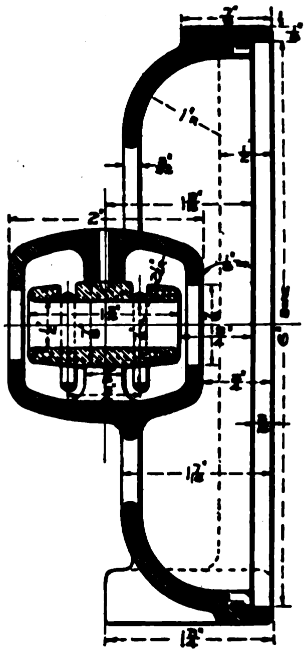


FIG. 4.—SECTION OF PLATE AND BOX.

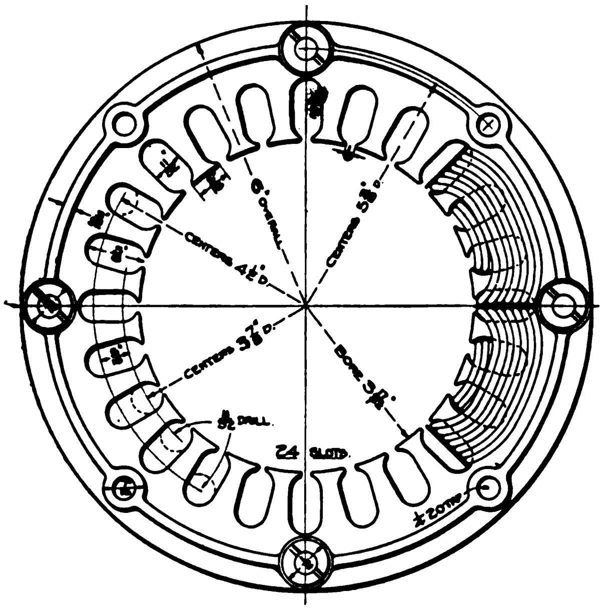


FIG. 1.—END OF STATOR.

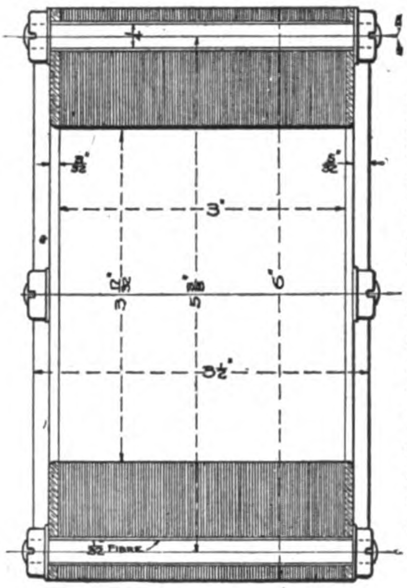


FIG. 2.—AXIAL SECTION OF STATOR.

The diameter of the armature may be determined by allowing a fair value of peripheral velocity which is limited by mechanical considerations but may run up as high as 6000 ft. a minute; 3½ ins. have been adopted in this case, which gives a peripheral velocity of 3500 ft. per minute.

The bore of the field will be larger than the armature by just as small an amount as possible for mechanical clearance. It is very important to keep the length of the air-gap low, since the running qualities of the machine will in a large measure depend upon this. The length of air-gap varies with the diameter of armature and for the present machine should not exceed from 1/64 to 1/50 in.

CONSTRUCTION OF THE MOTOR.

Fig. 1 is an end view of the primary core, which shows the form and layout of the slots. This shape of slot has the considerable advantage that it does not require elaborate dies and a punching press

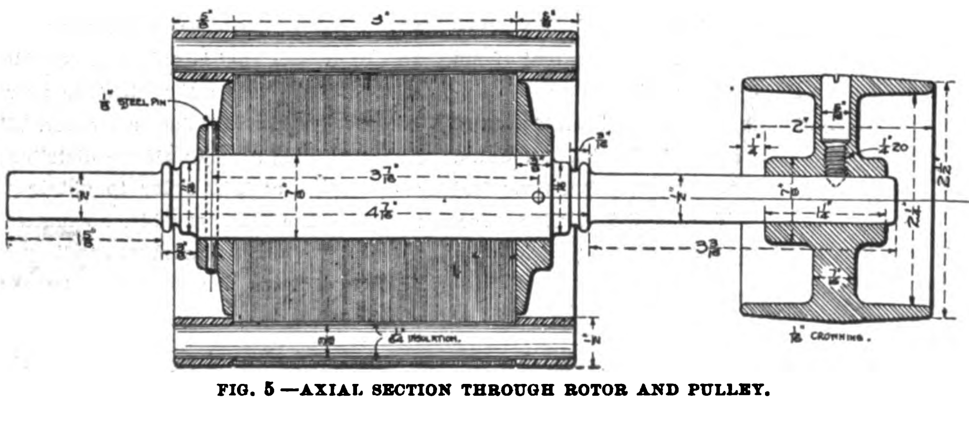


FIG. 5.—AXIAL SECTION THROUGH ROTOR AND PULLEY.

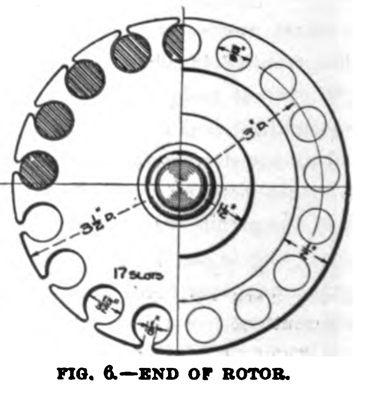


FIG. 6.—END OF ROTOR.

for its manufacture, but is easily made with no other tools than an ordinary twist drill and a file.

Plain round punchings are used and these are firmly clamped between two temporary cast-iron flanges about ¾ in. thick. One flange has a circle 3⅞ ins. in diameter drilled with 24 11/32 in. holes, and the other a similar circle 4⅛ ins. in diameter. The punchings are drilled first from one side using the 4⅛-in. circle, then from the other side using the 3⅞-in. circle. The flanges serve as a jig to guide the drill and prevent it from running over.

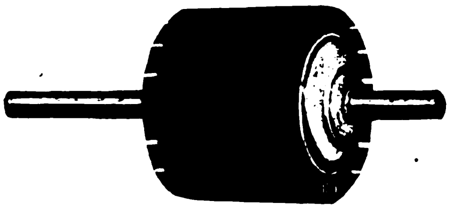


FIG. 7.—ROTOR CORE.

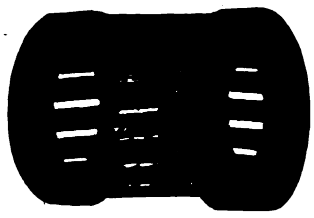


FIG. 8.—SQUIRREL CAGE.

The slots are smoothed up with a file where the two circular arcs meet and the thin bridge of metal separating the slot from the bore of the field is sawed or filed through and the edges slightly rounded. While the discs are still clamped in the flanges four 5/16-in. holes are drilled for the ¼-in. rods which are to hold the punchings when permanently assembled.

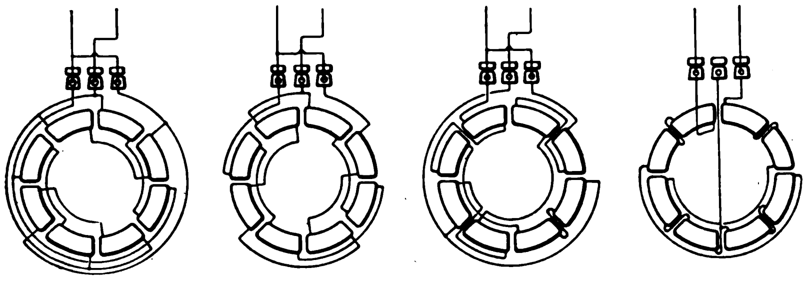


FIG. 9.

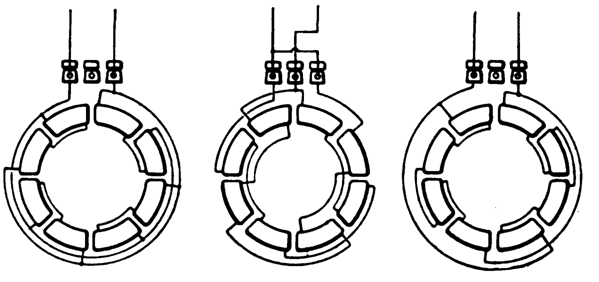


FIG. 10.

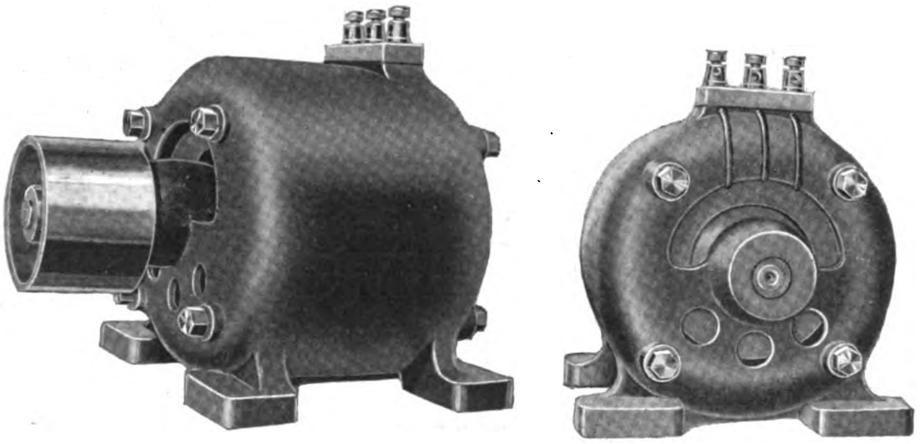
All this machine work being finished, the discs should be marked, as the spacing of the holes may not have been perfectly uniform, and then they are taken apart for insulating with shellac and thin paper before the final assembling.

When built up in the final form the discs are held between two light brass castings which are cast with the slots in them, the edges of which have been rounded on the pattern to avoid cutting the insulation when winding the core.

Four ¼-in. rods pass through the core and are provided with nuts at the ends; the discs are compressed by means of temporary bolts passed through the slot holes. Great care should be taken to insulate these rods from the core and the end discs, as otherwise this system of rods and discs will form a closed secondary circuit of low resistance which will permit waste currents and heating of the core.

Fig. 2 shows the arrangement of the holding together rods with their washers and insulating tubes. This arrangement takes only a small amount of the space otherwise available for winding. Fig. 3 shows an end view of the combined bearing and cover plate. This is cast with a semi-circular opening at the top and three round holes at the bottom, providing for ventilation and at the same time protecting the primary winding. Four lugs are cast on the rounded portion of the cover to serve as seats for the ¼ x 1¼-in. hexagon cap screws which fasten the cover plate to the primary core. A seat for the connection board is also provided on top of one of the covers, this piece being removed from the pattern before casting the other cover.

Fig. 4 shows a section of the bearing and arrangement of the oiling device. There is a little point about getting the oil rings and sleeve into place which could not well be shown on the drawing, and will require some explanation. The rings are first introduced into their compartments, but as they are about ⅛ in. larger in external diameter than the ⅞ in. hole at the end of the bearing, a horizontal slot has been cored out here to allow the ring to drop in easily.



FIGS. 11 AND 12.—COMPLETE MOTOR.

The brass sleeve which is ⅞ in. in diameter at its central part is next introduced through the ⅞-in. hole and secured in position in the central web by means of a small steel pin driven in from above. The rings are now fished into their respective grooves in the sleeve by means of a piece of wire inserted at the ends of the bearing. The rings are secured against coming out by bending down over the tops of the grooves small brass clips or pins which have previously been soldered to the sleeve.

The only machine work necessary on this casting is to bore out the center ⅞ in. in diameter and the ends 6 ins. in diameter for a distance of 3/16 in., so that the cover plate will just slip over the punchings. The cover plate is of cast-iron and the sleeve and rings are of brass.

Fig. 5 shows a section through the rotor and pulley. The core is built up of laminated iron in the usual manner. The discs are compressed between two cast-iron flanges and these are fastened to the shaft by means of ⅛-in. steel wire pins driven in after the pressure has been applied. A convenient way of applying compression to the discs is by means of the tail stock and screw of a lathe. The slots in the rotor core may be made in the manner described for the primary slots. They are 17 in number, 13/32 in. in diameter round.

Fig. 6 is an end view of the rotor when constructed as a squirrel-cage armature. The squirrel-cage is the best and simplest construction, and on the whole gives better results in very small machines. It consists of ⅜-in. copper rods passing through the slots and soldered at the ends to heavy copper rings. This system of winding is sometimes used without insulating the conductors from the core, but in this machine an allowance of 1/32 in. has been made for insulation.

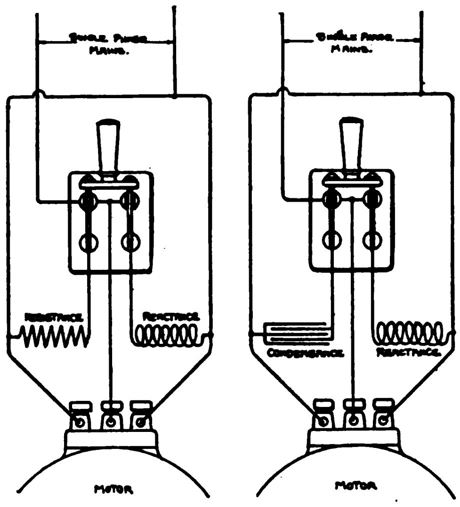
Figs. 7 and 8 show the armature core alone, and the squirrel-cage as it would appear separate from the core. It will be noticed that the slots are slightly spiralled by twisting the discs; the object of this is to eliminate any tendency to "lock" with the stator.

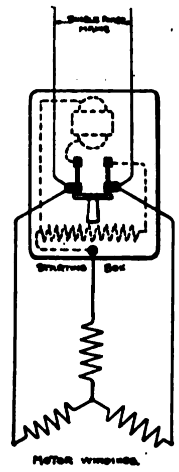
The voltage in the secondary is very low, never exceeding one volt in this machine, so that if the insulation stands a test with an ordinary door bell and cell of battery it will be ample.

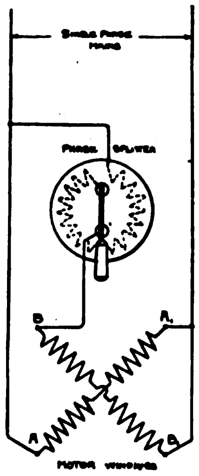
WINDINGS AND CONNECTIONS.

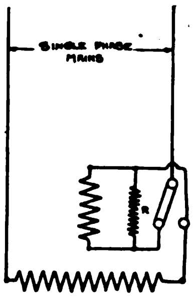
When all the machine work has been done on the motor and it is certain that no trouble or necessity for further machining will arise on the final assembling, the winding and connecting of the core may be taken up. The primary is wound with eight coils occupying positions as shown in Fig. 1, where two of the coils are represented in place. The ends of the core and the interior of the slots are first insulated with cotton cloth or oil paper, laid on with shellac. Insulation 1/64 in. thick has been allowed for in the slots.

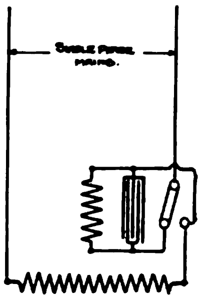
The winding is begun by filling the slots at either side of the tooth which is to occupy the center of the coil. When these are full the winding is continued in the two adjacent slots until these are half-filled; the coil thus completed should have 54 turns, or 36 wires per full slot.

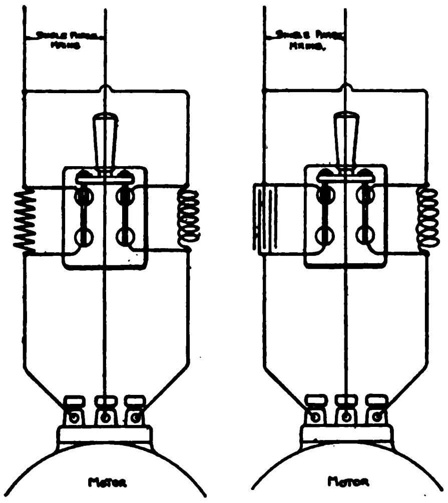

Single Phase Mains.
Single Phase Mains.
Resistance
Reactance
Condensance
Reactance
Motor
Motor
FIG. 13.—SHUNT PHASE SPLITTERS.

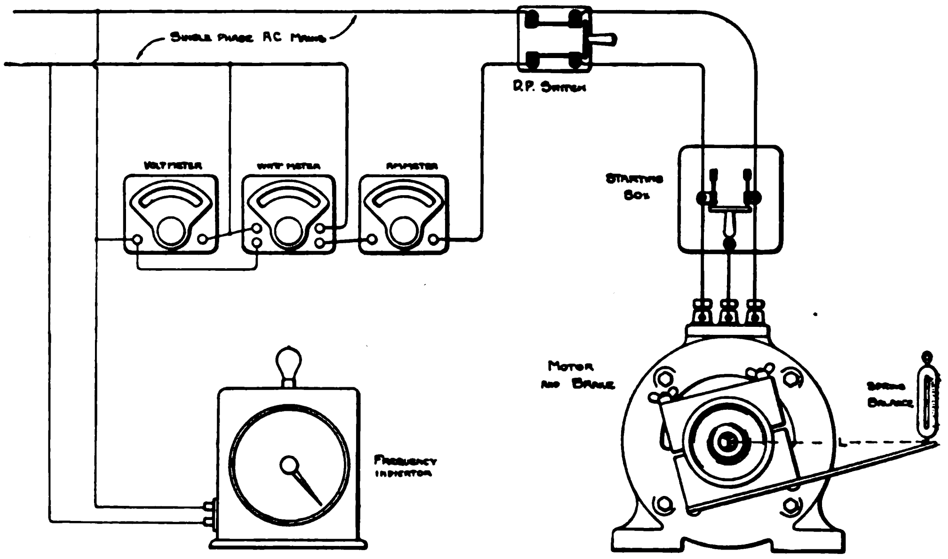

Single Phase Mains
Starting Box
Motor windings
FIG. 15.


Single Phase Mains
Phase Splitter
B
A
A
B
Motor windings
FIG. 16.


Single Phase Mains
R
FIG. 17.


Single Phase Mains.
FIG. 18.


Single Phase Mains
Single Phase Mains.
Motor
Motor
FIG. 14.—SERIES PHASE SPLITTERS.


Single Phase AC Mains
D.P. Switch
Volt meter
Watt meter
Ammeter
Starting Box
Motor and Brake
Spring Balance
Frequency indicator
L
FIG. 19.—CONNECTIONS FOR MAKING A PRONY BRAKE TEST.

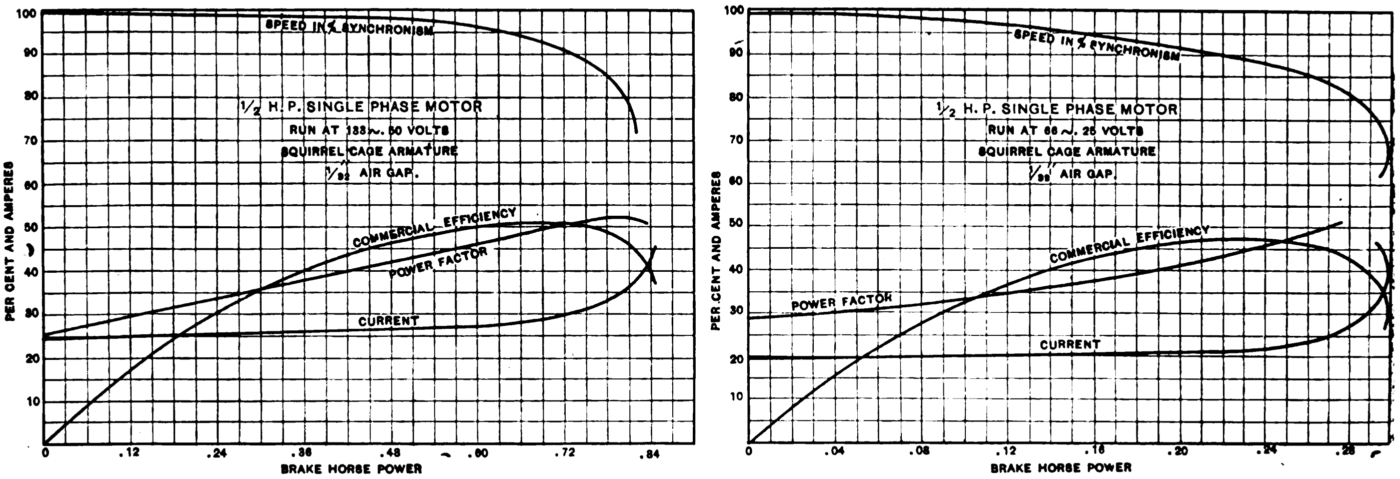


FIG. 20.—CHARACTERISTIC CURVES TAKEN FROM ½-H.P. INDUCTION MOTOR.

A slightly greater or lesser number of turns will answer, but all of the coils must have the same number of turns, whatever it may be, and it is best to count the turns as they are laid on.

The coils having been wound, the builder may take his choice of several different methods for connecting up. Fig. 9 shows what may be called the high-speed connections, there being four arrangements, for different voltages and frequencies. The coils are supposed to be all wound in the same direction and the drawing represents the beginning terminal of each coil as leading out from the inside of the coil and the ending as leading out from the outside. With any of these arrangements the speed will be from 3600 to 3750 r.p.m. and the rating of the motor ½ horse-power.

Fig. 10 shows how the same coils may be connected up for slow speed—from 1800 to 1875 r.p.m.; three arrangements are shown for different voltages and frequencies. Still other arrangements are possible, giving eight and sixteen poles, but these would not be of much practical value on account of the small output at such slow speeds. The pnase splitter cannot be used with any connection giving more than four poles. With any of the arrangements shown in Fig. 10 the output will be about ¼ horse-power.

OPERATION AND TEST OF MOTOR.

Naturally the first proceeding in operating the motor is to get it started, and Figs. 13 and 14 show some of the arrangements for doing this. No phase-splitting device has yet been discovered which will start a motor of this type with full load torque and anything like the full load current. The motor itself when thrown on the mains with the armature at a standstill takes twice the full-load current. In addition to this the phase splitter is usually proportioned to take a current equal to the full-load current of the motor, so that the total current for the combination is about three times the full-load current and the torque developed under these circumstances is from one-half to three-quarters of the full-load torque. This excessive current is, however, only required for a very few seconds.

Two arrangements shown in Fig. 13 are those employing reactances, resistances, etc., in multiple with the two stator windings. In starting, the double-pole switch is closed and after the motor has reached about two-thirds the normal speed it can be opened, thus cutting the phase splitter out of circuit.

The other two arrangements, Fig. 14, put the phase-splitting devices in series with the two stator windings. Here the switch is open at starting and closed after the motor has attained some speed. If operated at the same supply voltage as the multiple arrangement, the series arrangement takes less current, but the torque developed will also be less. By raising the applied pressure almost and desired torque may be obtained.

No definite instruction can be given for the values of resistance, reactance and condensance, as these will depend entirely on the torque which it is desired to obtain. In general, it may be said that in making up the reactance coil its resistance should be kept as low as possible, and in making up a resistance care should be taken to have it non-inductive. For condensance an electrolytic cell is suggested, consisting of thin sheet-iron plates immersed in a solution of common soda and separated by thin fiber strips. A cell of this kind is mostly pure ohmic resistance, but there is some capacity effect present, and this is, of course, beneficial.

Figs. 15 to 18 show diagrammatically some starting devices used by various electrical companies, which may be of interest in this connection. The General Electric Company uses a resistance and reactance in parallel with the motor windings, as in Fig. 15. The switch is closed at starting and open when motor is in normal operation. The Westinghouse Company uses a simple resistance placed in series with a special starting winding on the motor, as in Fig. 16. The switch is closed at starting and afterward opened, cutting out the resistance and the starting winding.

Messrs. Brown, Boveri & Co. use a starting winding displaced 90° in phase position from the main or working winding, as indicated in Figs. 17 and 18. For motors of small size—up to ½ horse-power—a simple resistance is placed in parallel with the starting winding (Fig. 17), the switch being in the position shown for starting and afterward moved over to the other button. Fig. 18 shows the arrangement for motors from ½ to 5 horse-power, where a condenser of the liquid type already mentioned is used. In motors above 5 horse-power, this company uses a starting resistance in the rotor.

It may be well to state here that all methods of this kind for starting are covered by patents, but there will be no objection to their use non-industrially by individuals.

Fig. 19 shows an arrangement for testing a single-phase induction motor under brake load. Readings are taken of volts, amperes, watts input, speed of motor, and frequency of generator, for various loads up to the "break-down" point of the motor. The number of pounds pull indicated on the spring balance multiplied by the length of the brake arm, L, gives the torque of the motor. From the readings thus taken, the complete performance of the motor can readily be computed. Fig. 20 shows curves for the motor here described, which were obtained by this method.

INTERIOR TELEPHONE SYSTEMS.

BY W. S. HENRY.

INTERCOMMUNICATING SYSTEMS.

In Figs. 21 and 22 of the September article the connection between the receiver and the upper contact of the key, K, at each station could just as well be carried directly to the lever of the selective switch, S, eliminating the upper contact of each push-button.

In Fig. 24 is shown an arrangement in which one conveniently located common battery, C B, supplies current for ringing and also for all the transmitters. This system is very similar to that illustrated by Fig. 21 in the September issue. No matter where the lever of the selective switch is left, the bell can still be rung, but conversation cannot be carried on until the switch at the station called is returned to the home button. This system includes a piece of apparatus at each station that has not been required in any of the systems previously described, to-wit: the impedance coil E. Where a common battery supplies all the local microphone circuits with current in systems of this kind, there is very apt to be cross talk between two pairs of telephones that may be in use at the same time, in which case the battery will be supplying current to four microphones.

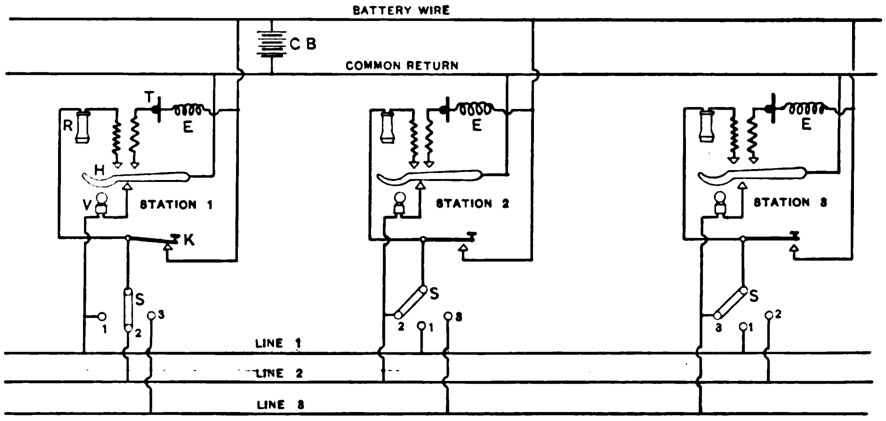


FIG. 24.—COMMON BATTERY SYSTEM WITH IMPEDANCE COILS.

The cross talk is due to the variation in the fall of potential along the battery and common return wires. When one microphone is set in action it will cause a variable current to flow through the common return and battery wires and hence cause a variation in potential at the points where other microphone circuits are tapped on; consequently, a variable current will be set up in the microphone circuit of any other telephone set that may happen to be connected to the battery circuit at the same time. This variable current flowing through the primary coil induces a current in the secondary that causes the cross talk in the receiver at that station.

The cross talk may be greatly reduced by using batteries of very low internal resistance, such as storage cells, and by making the common return and battery wires extra large, that is, small in resistance, so that the variable fall of potential through the battery and in these two wires may be small. By keeping the resistance of the battery and the two wires low enough, the potential at all points along the two wires, no matter how much the current may vary, will remain ~~nearly enough~~ constant so that no appreciable variable currents are produced in the other microphone circuits and therefore no cross talk in the telephones However, it is impractical to make the resistance of these two wires low enough, especially where they are of considerable length, to eliminate all cross talk.

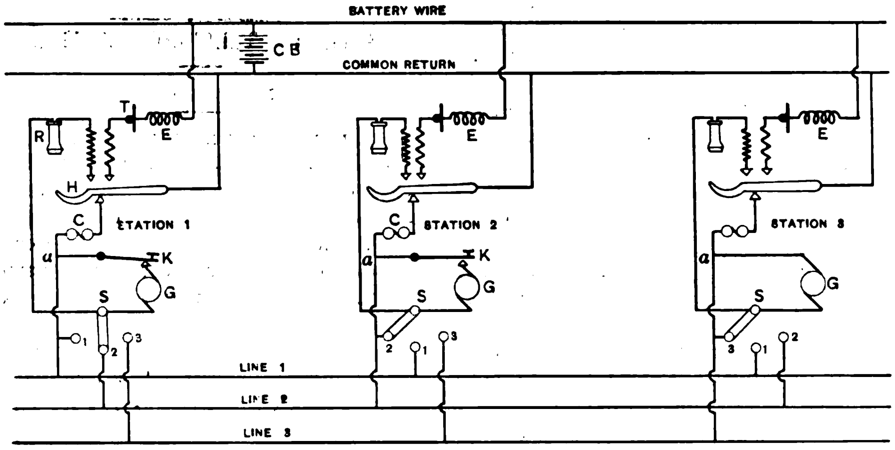


FIG. 25.—COMMON-BATTERY SYSTEM WITH IMPEDANCE COILS AND MAGNETO SIGNALLING APPARATUS.

Another way to reduce the trouble from cross talk is to insert an impedance coil in each microphone circuit, as shown in Fig. 24. This makes the impedance of each microphone circuit large compared to that of the two lines and battery, and in order to get the same current as before in each microphone the e.m.f. of the battery must be increased. Hence the same actual fluctuation in the line voltage is now a smaller percentage of the total voltage, and the higher impedance of each individual microphone circuit still further reduces the strength of the cross-talk current in the various microphone circuits. These impedance coils reduce the efficiency of the system, but the reduction in cross talk compensates for this loss to a great extent.

Fig. 25 shows the same system, except that magneto-bells and generators are used in place of the vibrating bells; the common battery, located in any convenient place, supplies current for all the microphones. Impedance coils, E, are usually necessary for the reason explained in connection with the preceding system. The switch, K, at Stations 1 and 2 is held closed while turning the generator. The switch is omitted at Station 3. The system would ordinarily work satisfactorily without these switches, but their use prevents all possibility of the ringing current dividing when it reaches the point, a, at any station in case the selective switch, S, at that station should not be on the home button.

The remarks in reference to Fig. 24, so far as the signalling apparatus is concerned, apply also to this system. The selective switch, S, should always be returned to the home button, although failure to do so will not prevent the bell from ringing when the station is called up. The great advantage of the systems shown in Figs. 24 and 25 is the ability to use induction coils without using any batteries at the various stations. The tendency to cross talk is a disadvantage.

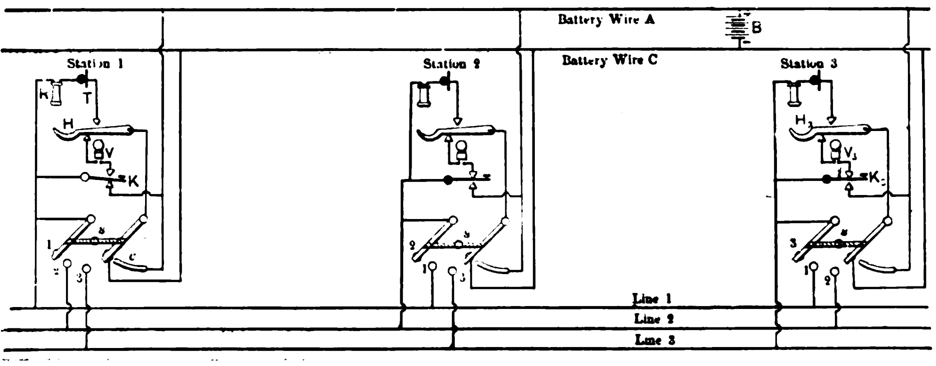


FIG. 26.—COMMON BATTERY SYSTEM WITH SPECIAL SELECTIVE SWITCH.

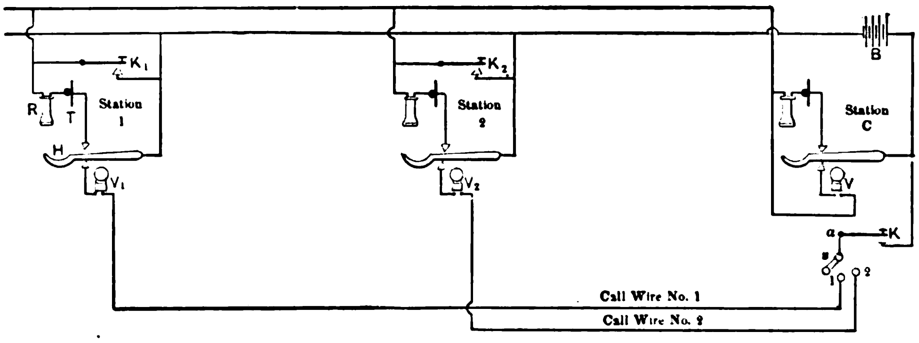


FIG. 27.—RADIAL SYSTEM; SELECTIVE AT ONE STATION ONLY.

Fig. 26 is a system with ordinary transmitters, receivers, vibrating bells, push switches, K, and a special switch, S, at each station. One common battery, B, answers for both ringing and talking. There is no battery or induction coil at any station. One common battery, B, is located at any convenient point and connected between the two battery wires, A and C. All the telephones may be in use at the same time in sets of two, each connected pair being independent of the others. The battery in this system must be strong enough for talking or ringing between the two most distant stations.

There are two more wires throughout than there are stations. The switch, s, is a double-pole strap switch, with an insulating strip connecting the straps so that both move together. As soon as the left-hand strip leaves the home button its mate leaves the button, o, and slides upon the brass segment, c. This double-pole switch is necessary in order to disconnect the calling station from battery wire C, and connect it instead with battery wire A, and so connect the battery in series between the called and calling stations.

Suppose Station No. 1 desires to talk with Station No. 3. The switch, S, at Station No. 1 should be turned to the right until the left-hand strap rests on button 3, and the push, K, depressed, thus cutting out the home bell, V. A circuit may then be traced from the positive pole of B, through battery wire, A, key, K, switch, S, button, 3, at Station No. 1, line 3, contact, 1, at Station No. 3, bell, V3, hook switch H3, switch, S, and battery wire C, to the negative pole of the battery. Thus only the bell V3 will ring. When the receivers are removed from the hooks at Stations 1 and 3, the two receivers, transmitters, and the battery are all in one series circuit in the proper relation for talking. The switch, S, must be returned to the home position, otherwise if left upon button 3 and Station No. 2, for instance, should attempt to call up Station No. 1, then the bell at Station 1 will not ring, but the bell at Station No. 3 will ring instead. However, as soon as two parties finish talking and both receivers are hung up both bells will ring until the switch, S, is returned to the home position. An automatic device that either returns the switch, S, to the home position or compels the user to do so before he can hang up the receiver is used in some systems to obviate this trouble.

It sometimes occurs that a system is required so arranged that one station can call up any one of the others, but the others can call up and converse with the first station only. Fig. 27 is a diagram of such a system; Station No. 1 or No. 2 can call up Station C by merely depressing the push switch, K1 or K2, but they cannot call up or converse with each other. Station C by means of the switch, S, and push, K, can call up either Station No. 1 or No. 2. There are only two wires that must run through all the stations. There is one wire, however, from Station C to each one of the other stations. These wires, Call Wire No. 1 and Call Wire No. 2, are used only when Station C calls up one of the other stations. One wire could be made to answer if there was no objection to having all but the home bell ring when Station C makes a call. In this case a certain number of rings would be necessary for each station except C and the one common call wire would be connected to the signalling key at a, Station C, and there would be no need of the switch, S.

As arranged in the diagram, the push switch, K, is normally open. When Station C desires to call Station No. 2, for instance, the switch, S, must be turned to button 2 and the push switch, K, depressed. The one common battery, B, furnishes current for all ringing and talking. At each station there is an ordinary receiver, microphone transmitter, and vibrating bell. There is only one bell in circuit when a call is made so that each bell must have a vibrator. It makes no difference upon what button the switch, S, is left.

THE ELECTROLYTIC PRODUCTION OF SODA AND CHLORINE.

BY JAMES F. HOBART.

The three-tank triple-fluid syphon-diaphragm electrolytic cell deserves more than passing notice. Such an apparatus is illustrated in Fig. 17. There are several forms of these fluid cells, some of which are illustrated herewith. The syphon diaphragm cell, Fig. 17, seems to possess infinite possibilities and is apparently worthy of close consideration. This diagram may be said to represent a combination of the processes already described. In the elevation it is shown that the diaphragms are formed of tubes, which are filled with some porous material, so as to act by capillary conduction; asbestos and porous cement are two materials used for filling the tubes. As shown by the plan view, the diaphragms may either be small round tubes or they may be large flat ones, only one or two being required for each diaphragm; both kinds are shown in the engraving. The round tube diaphragm is more easily made, handled and kept in repair, but the flat tube has the lower electrical resistance, hence it gives the better results.

The value of diaphragms of this kind lies in the ease with which they may be applied to any vessels of the sort and shape suitable for electrolytic cells; also in the fact that the vessels themselves may be employed as anode and cathode.

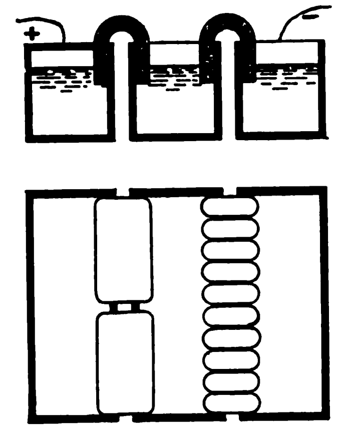


FIG. 17.—SYPHON-DIAPHRAGM PRINCIPLE.

When a single tank or cell is fitted with one or more diaphragms, measures must be taken to construct the cell of non-conducting material, otherwise a good deal of electric energy will be lost by conduction. A great disadvantage of this form of diaphragm is its thickness, which causes a great deal of internal resistance. To obviate this fault the tubular diaphragm was evolved into the plate form, which is shown by Fig. 21.

In the operation of the three-tank triple-fluid syphon-diaphragm cell the liquid in the left-hand tank becomes saturated with chlorine until no more of that gas will be held in solution in the water contained in that division of the cell. After the liquid has become fully saturated—become dilute hydrochloric acid, in fact—the chlorine will bubble up and pass off as fast as it is formed. In the cathode tank the soda deposited combines with the liquid in like manner, and the solution may be drawn off when found to be sufficiently concentrated; but in first starting this kind of a cell to work it will be found impossible with any reasonable e.m.f. to force current through the three cells after they have been freshly filled, the middle one with salt solution and the others with pure water. To obviate this difficulty it is necessary to put a few pounds—the quantity varying according to the size of the tank—of HCl into the left-hand compartment and to dissolve some soda in the other tank. This gives the water sufficient conductivity to enable the current to pass; once started, the current will soon deposit enough of both elements to establish the proper conductivity, and the conductivity will increase up to the point of saturation.

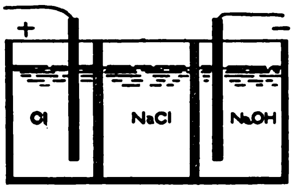


FIG. 18.—THREE-FLUID CELL.

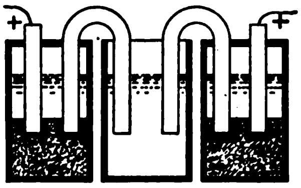


FIG. 19.—DUPLEX CELL.

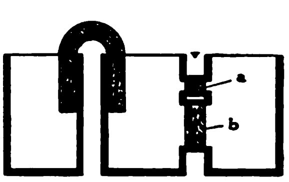


FIG. 20.—DIRECT DIAPHRAGM.

Probably the purest ions can be obtained with an electrolytic cell of this kind, or with the kind illustrated by Fig. 18. Here the syphon arrangement has been modified into a simple division, as shown more fully in Fig. 21. In Fig. 18 a single tank contains the three fluids, which are separated by two diaphragms. Otherwise the operation of this cell is precisely like that just described and illustrated by Fig. 17.

Fig. 19 represents a three-fluid cell known as the "Duplex." The middle tank forms the cathode, while two anodes are used, each being in a separate cell of its own. The syphons used in this cell are filled with a salt solution, there being no asbestos or other absorbent material inside of the syphons. The "straining" action is secured by burying one end of each syphon in the carbon of the anode which it serves.

At first sight this form of construction appears to settle the diaphragm question, but upon studying more closely the matter, grave defects are apparent. The ions are liberated at the surface of each electrode, and the points directly opposite each other have never less than their regular share of the work; therefore the part of the anode which closes the tube becomes the most effective part of that terminal. Hence, the greater proportion of the ions are liberated inside of the tube, and in the case of chlorine and hydrogen they rise to the highest part of each tube where, if not drawn off by a pump, they have the effect of cutting off the electric current entirely as soon as the tube is filled with gas at the bend.

It is evident from the form and nature of syphon diaphragms that they were suggested by and are modifications of the "wicking" connection between cells shown by Fig. 11 (August article). The wicking was threaded through a tube to keep it in shape and to prevent it from becoming dried up, soiled or injured by careless handling. It was found that the elements soon decomposed the cotton wicking, and resource was had to asbestos or some other material not subject to electrolysis; hence the evolution of the syphon diaphragm.

In using this form of connection between two cells it did not take long for the experimenter to become acquainted with the faults of the device, to obviate which he shortened the long tube and connected the two tanks or cells direct, as shown at a, Fig. 20, instead of running over the top, as shown on the left. The shortness of the tube proved so great an advantage that it was enlarged, as at b, and the next step was to further shorten the length of the tube and to increase its area until it covered the whole side of the cell and became a plate or film. No sooner was this improvement effected than trouble began in another quarter. The big thin diaphragm, although electrically satisfactory, would not remain in place; it would buckle and go to pieces. One result of the numerous efforts to obtain a satisfactory diaphragm has been the abandonment of vertical diaphragms and a dependence principally upon the difference in the specific gravities of the fluids to keep them separate, the dividing line being horizontal instead of vertical, as in the ordinary bluestone primary cell. Fig. 21 shows such a cell in which, however, the separation of the fluids is facilitated by very thin mechanical divisions.

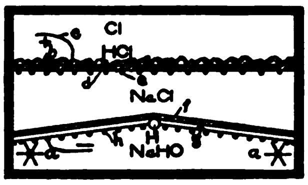


FIG. 21.—HORIZONTAL DIAPHRAGMS.

In this cell, which must be built of glass, slate, or some insulating and noncorrosive material, there are two light diaphragms of asbestos cloth, or some other similar material. The upper diaphragm, d, is laid on a lattice work or grating, e, of non-corrosive rods; directly on this diaphragm the anode material is laid, which may consist of lump carbon packed evenly all over the surface of the diaphragm. The positive wire, c, is connected to the carbon, and it will be well to use platinum wire inside of the cell and to make several connections with lumps of carbon in different parts of the mass in order to insure good conductivity between all of the pieces of carbon and the terminal.

The lower diaphragm, f, is laid on a similar grating of iron; or iron rods or pipes, h, may be put in and iron strips, g, may be laid upon the rods; then iron wire netting is spread over the iron strips and the asbestos cloth is placed upon the netting. This makes a strong form of diaphragm, and the iron in its support serves as the cathode. The strips, g, are used to provide a number of uninterrupted passages to the pipe, H, which carries off the hydrogen gas evolved during electrolysis. The negative terminal is connected to the iron grating, as shown near h. A couple of agitators, a, a, are provided to keep the electrolyte in motion, so that gas will not adhere to the cathode and cause polarization. The lower diaphragm is made roof-shaped for the purpose of leading the gas to its pipe and facilitating its exit from the cell.

In operation the tank or cell is nearly filled with a saturated salt solution (NaCl), leaving sufficient room at the top for the chlorine to accumulate. Current being turned on, the ions are separated, and the upper and lower solutions gradually become nearly pure, and as indicated by the chemical symbols in the engraving. If it is desired to start the process so as to secure pure ions from the beginning, it will only be necessary to fill the lower compartment with water, fill the middle compartment with salt solution, and let in some water above the top diaphragm; there is no need of priming the cell with caustic soda and acid, as must be done with the three-fluid cells shown by Figs. 17 and 18.

The natural tendency of the three liquids is to keep apart, and this tendency is much strengthened by the passage of current; these two forces, augmented by the very light diaphragms, are sufficient to do all that is required in this direction.

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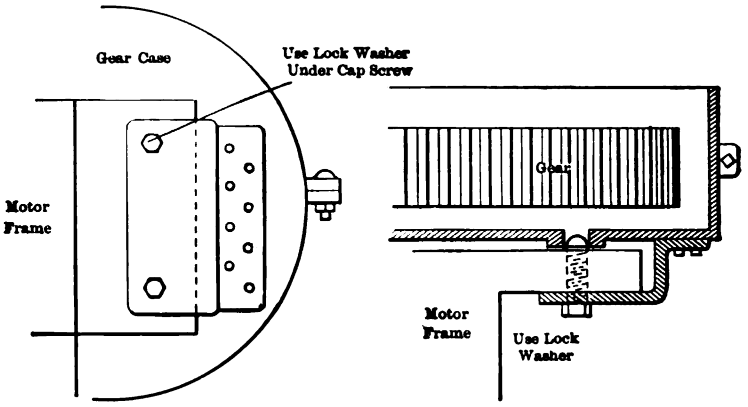
STREET RAILWAY CAR GEARS AND GEAR CASES.

BY A. B. WEEKS.

Is there anything more disagreeable to the public or to the manager of a street car line than the awful grind of uncovered gears, or that caused by the indiscriminate changing of gears and pinions? Where gear-cases are left off, owing to gear-bolts breaking and finding their way into the gears themselves and ruining both the gears and armature shaft, the only remedy is to buy gears which will withstand the most severe strain, and having bolts at least ¾ in. in diameter.

A certain well-known road bought up a large number of gears "at a bargain" and repented it for several years thereafter. They were too light for the work, and the bolts were but ⅝ in. in diameter. Broken shafts, ruined gears, delayed cars, extra work, etc., were the results. As a last resort the cases were left off, when some of the trouble was eliminated. It is an expensive thing to run gears without grease, and gear-cases are required to retain the grease. It is useless to smear grease upon the gears without cases, for the first few revolutions will throw off the greater part of it, and the grit that gathers on them soon finishes the remainder.



METHOD OF ATTACHING A RAILWAY-MOTOR GEAR CASE.

Some time ago the writer took charge of a plant in which all of the motors were running without gear-cases. In one of the pits all the cases were found thrown away and partly covered with mud and scrap. After digging several of them out, it was found that the holes for the bolts by which the cases were made fast to the motor were so worn that the threads would not hold. For this reason, the entire lot had been cast aside. Such a condition of gears the writer had never before seen. Malleable iron axle-gears and steel pinions worn to a knife edge, and in many instances the entire motors were covered with the iron cuttings.

The first attempt to replace these old cases was a dismal failure, owing to the iron lugs breaking off because of the blacksmiths having formed them the wrong way of the grain. The motors were standard Westinghouse machines. The bolt holes in the cases were so badly worn that they were not used at all. Where the holes in the frame were all right, they were tapped out so as to get a full thread, but new holes were drilled in the motor frame, rather than use a bolt larger than ¾ in. The accompanying sketch illustrates the method of attaching the case. Use ⅜-in. Swedish iron and rivet the lug on the case, using several 5/16-in. A-1 iron rivets. To lay out the holes, first put the case up in place, being sure it is set for the proper clearance above and below the gear.

A notable improvement was found in the street railway system referred to after the gears were all covered and running in grease.

"In removing your gear-cases to repair broken lugs," suggested an oil agent one day, "put the grease into a barrel, and keep it for greasing the tracks at curves and turn-outs." We found this a decided saving over the old method of burning out the grease.

Scraping the grease out and using it over again on the gears is unwise; for it is often found to contain rivet-heads, or a stray nut, which would invariably work into the gear. A bad accident of this sort once happened to a snow-sweeper on its first trip out, though the grease was taken from a fresh barrel in this instance.

One more thing about gears: How shall

they be kept tight? There is but one way —to make an absolutely perfect fit of the key and dowel pin, never slighting the work in the least. There will then be no doubt as to their remaining tight.

WHY ELECTRIC CAR WHEELS SLIP.

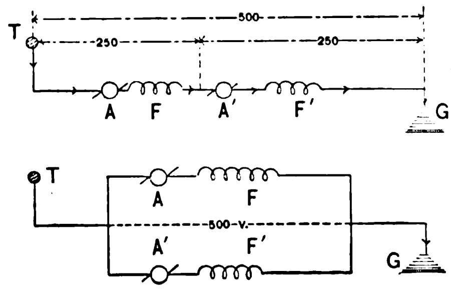
BY EUGENE C. PARHAM.

Under certain conditions one pair of wheels on a car will persist in slipping to such an extent that the car cannot be made to start at all. It is a fact noticed perhaps only by those who are interested in the running of the car, that such slipping generally takes place in curves or on grades and in its worst form on combinations of the two. It may seem peculiar that on grades the front pair of wheels, as a rule, do the slipping, while in curves it is generally the back pair. It is also a well-known fact among railway men that the wheels of double-track cars having four axles, but only two driving axles, slip worse than those of single-track cars having but two axles, both of which are drivers. In order to finally state the case and its causes clearly it must be stated that the motors used in street car work are series-wound motors and at starting they are, as a rule, connected in series. The same current, of course, passed through both and the line voltage divides between them when the two motors are running along under normal conditions, as indicated in Fig. 1.

After the car is started and running along with all of the resistance coils cut out and the motors in series, the resistance of the two motors is so low, compared to their counter e.m.fs., that it can be neglected. We will assume, then, that the internal ohmic resistance is zero, and that the two counter e.m.fs. in series alone limit the value of the current that the car takes. It is, of course, well known that the line voltage applied to any circuit distributes itself according to the resistance or opposition it meets; wherever the opposition or resistance is greater the drop is greatest. Referring to Fig. 1, if the two motors are electrically balanced; if they are geared so that one armature does not turn any faster than the other; if all of the car wheels are of the same size, and if the brush-holders are set right, the counter e.m.fs. of the two motors will be equal. We will assume for the present that they are, and, consequently, that the drop across each of the motors is the same.

The speed at which a motor will try to run depends upon the voltage applied to its terminals. If this voltage is varied, the speed will vary. This fact makes the behavior of two motors running in series very peculiar under certain conditions. As a matter of fact, unless the two motors are either very small or are rigidly connected to the same mechanism or to each other, they cannot be run in series at all. This is true not only of series motors, but of shunt motors, too. The two motors of a street car work together simply because the wheels attached to both motors rest on the rails and there is a certain amount of friction between the wheels and rails, so that the motors are in a sense geared together. The more weight there is placed on both motors and the drier the rails the less apt is either motor to slip, because there is more friction between the wheels and the rail so the wheels do not slip so easily.

Now, if we grease the rail well under one pair of wheels it will be found next to impossible to start the truck, especially if it is on a slight up-grade. As soon as the line voltage is applied the pair of wheels on the greased part of the rail start to spin and if the voltage is kept on they spin faster and faster. To the ordinary observer it seems strange that the motor geared to the pair of wheels that do not slip does not get to work and run the truck over the bad spot. There is a very good reason why it does not, and this reason will be more readily grasped later. Now jack the truck up so that both pairs of wheels are lifted entirely off the rail (when this is done the motors must be jacked up too to take the weight off the axles, otherwise the journals will run on the bottom of the boxes where there is no journal brass) and again apply the voltage. Both motors will start up in good shape, because the first rush of current is enough to start either of them, however badly it might be stuck.



FIGS. 1 AND 2.

After the motors start up the interesting part of the experiment ought to come; if one motor runs easier than the other, that is, has less friction in its moving parts, or if the motors are electrically or magnetically unbalanced, so that the counter e.m.f. of one is lighter than that of the other, one motor will be observed to gradually gain in speed and the other to lose correspondingly. The motor losing speed may stop altogether and it may not; whether it does or not depends upon a condition to be considered later. If it does stop it will not start again, unless the current is cut off and the other motor is allowed to come to rest before the current is applied again. If it does not stop it will at least run much slower than its mate does. An example of this kind of running is often seen in hotels, where ceiling fan motors are used to cool the dining room. Two motors are often connected in series and one can be seen to drive the fan blades a good deal slower than some of the others do. The slow motor does not stop because even the small current that its mate takes while running at high speed is sufficient to start it if it is very easy starting.

In the case of the two street car motors jacked up with the truck and running free, the speed of either motor can be increased by simply pressing a bar against the wheels of the other motor, giving it more of a load. If one end only of the truck is raised off the rail, the other end being left down, the action is about the same, when the voltage is applied, as in the case of the greased rail. The whole truck may give a little jump, due to the first rush of current, but it will not start.

All of these peculiar actions are due to change in the distribution of the line voltage. The line voltage drop across the motor depends upon its counter e.m.f. and this in turn upon its speed. If for any reason the speed of one motor drops a little its counter e.m.f. drops too. This allows the voltage at the terminals of the other motor to increase the total voltage remaining constant. Hence, the other motor speeds up so as to raise its counter e.m.f. to meet the increased voltage. Each little addition of voltage that the faster motor gets across its terminals causes its speed to go up a little and with it up goes the counter e.m.f. This further increases the effective resistance of that part of the circuit and robs the slower motor of more voltage, causing it to slow down still more. Of course, these interactions can take place only when the motors are in series, in which condition any variation in the speed of one motor will result in a contrary change in the speed of the other one. As soon as the motors are thrown in multiple, as in Fig. 2, each motor has an independent circuit of its own and each gets the whole line voltage across its terminals. If this line voltage is kept the same, ordinary variations in one motor circuit will not affect the other.

Now, in the case of a car climbing a steep grade, the car is in an inclined position and most of its weight is thrown on the rear wheels, so that they have good traction—even better than they have when the car is on a level. On the other hand, the front wheels have not their share of the weight, so that their grip on the rail is less than it is when the car is on a level. The result is that the resistance to the rotation of the front axle is so low that it is an easy matter to send through the two motors current enough to turn the front axle independent of the rail. As soon as the front axle begins to turn the counter e.m.f. of its armature runs up and monopolizes most of the line voltages; this causes a further increase in the armature speed, with the result that the wheels get to spinning and then there is no hope of moving the car, because the counter e.m.f. of the spinning armature cuts the value of the current down so that the rear motor, which has good traction, has no power to move the car.

The only thing to do in such a case is to throw the power off, give the rail sand and throw the power on again, more gradually. It sometimes helps matters a little to take up the brakes about a half a turn; this keeps the wheels from spinning so readily. As a final resource it may be necessary to throw the motors over to multiple; in such a case the controller should never be carried further than the first multiple notch until the car has fairly started.

If a man does not know how to take a car around a curve, or if he allows his car to stop in a curve, there is more wheel slipping; but, as above stated, it is the rear wheels that slip, as a rule, because the forward ones are further around the curve and are more tightly bound. After one pair of wheels begins to slip the car loses its traction for the same reason that it did in the previous case. In the case of the curve, it is a waste of power and wheel treads to keep the current on steadily and try to have the car grind itself out of the curve. The first thing to do is to set the brake up a little, give the rail sand and throw the power on and off. If this does no good, give the controller one reverse notch and as soon afterward as possible a notch ahead, and at the same time have as many passengers as possible jump up and down on one of the platforms. This will generally get the car out. If it does not, the only thing to do is to throw the motors over to the first notch in multiple. The best way to avoid all curve troubles is never to allow the car to stop in the curve, even if it does shake up the passengers a little.

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INTERIOR WIRING.

BY CHARLES E KNOX.

THE WIRING OF AN OFFICE BUILDING.

The building selected for the purpose of illustrating this article is an eleven-story structure recently erected at 7 Wall Street, New York City. This building was selected as the first of a series of practical examples of interior wiring, on account of the relative simplicity of the wiring scheme, and also on account of its being typical of a large number of office buildings. It is an L-shaped structure, with a cellar and basement and eleven floors above. The approximate total cubical contents of the building is about 600,000 cu. ft. Figs. 1, 2 and 3 are plans of three characteristic floors, viz., the cellar, first or ground floor, and one of the other upper stories. The other stories are almost identically like Fig. 3, so that these diagrams will serve to illustrate the wiring of the entire building. The building is wholly devoted to office purposes, with janitor's quarters on a portion of the top floor.

The construction is fireproof; the outside walls are of brick, furred in the usual manner on the inside. The partition walls around the stairs and elevator shaft are built of terra cotta blocks. All the remaining partitions are of wood (1 in. thick) and glass. The floor construction is peculiar. It consists of the usual terra cotta arches, with the space between the top of the arches and the beams filled in with ashes and cement. The space, however, between the tops of the iron beams and the under part of the rough floor is only 1 in. instead of the usual 3 in. This was due to the fact that instead of using 3-in. sleepers, grouted in with concrete, 1-in. wood sleepers were used. These strips were strapped to the iron beams at the points where they crossed them. This limited space made it absolutely necessary to avoid crossing the conduits at any point, as such crossing would bring the conduits above the rough floor. There are two layers of flooring, a rough and a finished floor.

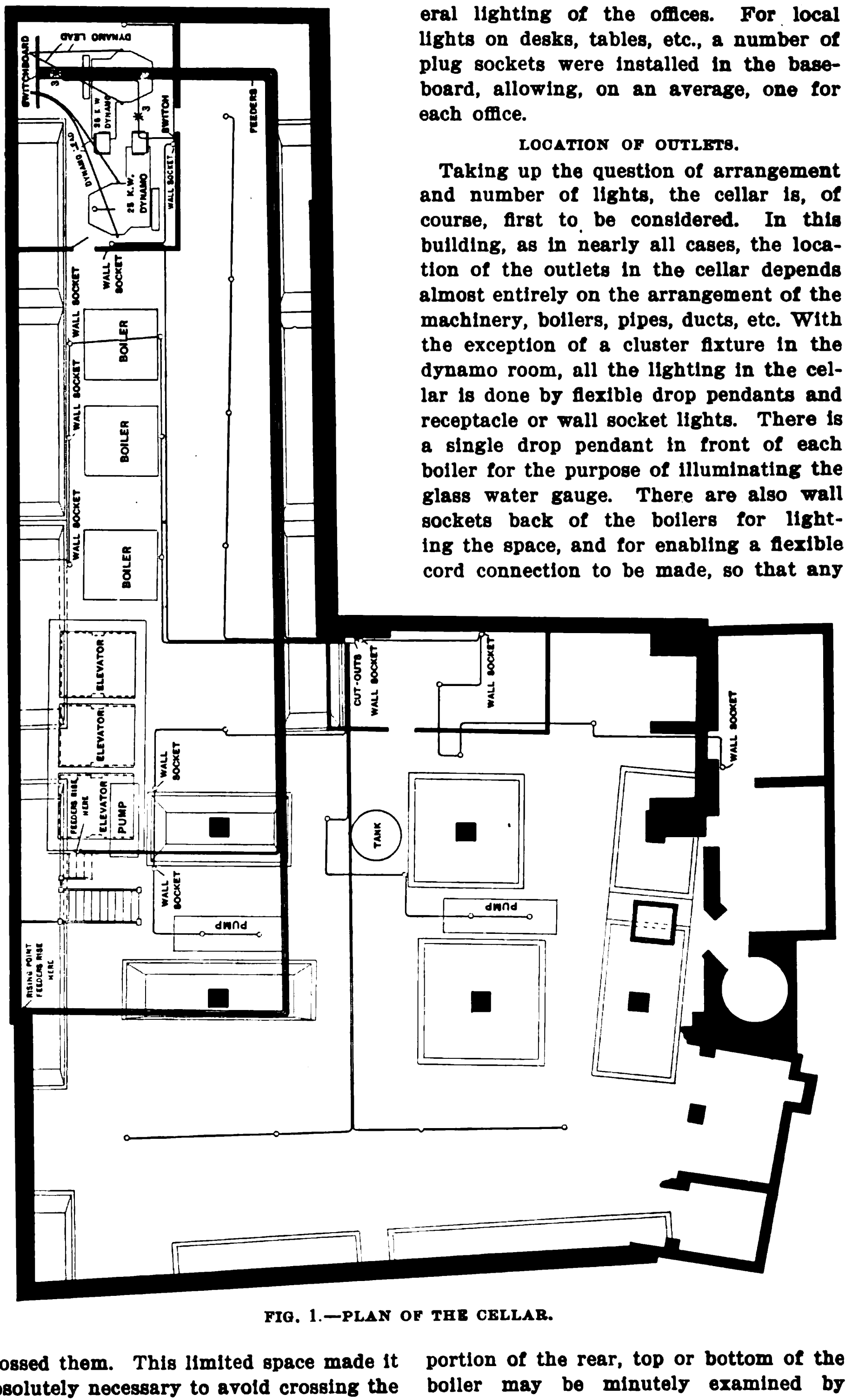

FIG. 1.—PLAN OF THE CELLAR.

Coming to the question of lighting, it will readily be seen that on account of the partitions between the offices being of wood and only 1 in. in thickness, it was impossible to use side-bracket fixtures in the offices, except on the outside walls. Furthermore, all the partitions between the offices were built after the flooring was finished, it being the architect's plan to make these partitions removable without disturbing the floors. As the outside wall space was limited and was further reduced by steam pipes and the partitions, it was decided to depend entirely on ceiling fixtures for the general lighting of the offices. For local lights on desks, tables, etc., a number of plug sockets were installed in the baseboard, allowing, on an average, one for each office.

LOCATION OF OUTLETS.

Taking up the question of arrangement and number of lights, the cellar is, of course, first to be considered. In this building, as in nearly all cases, the location of the outlets in the cellar depends almost entirely on the arrangement of the machinery, boilers, pipes, ducts, etc. With the exception of a cluster fixture in the dynamo room, all the lighting in the cellar is done by flexible drop pendants and receptacle or wall socket lights. There is a single drop pendant in front of each boiler for the purpose of illuminating the glass water gauge. There are also wall sockets back of the boilers for lighting the space, and for enabling a flexible cord connection to be made, so that any portion of the rear, top or bottom of the boiler may be minutely examined by means of a lamp at the free end of the flexible cord.

Taking up next the arrangement of outlets on the first floor, the problem presented itself of lighting a space the ulterior use and arrangement of which was of course, unknown. This being the case, it was only possible to locate the outlets at such points as would cover the greatest possible number of arrangements of the space. As it was not likely that partitions would be run into the centers of the windows, but would more probably be placed opposite the piers between the windows, the outlets were located opposite the centers of the windows. (See Fig. 2.) This would probably bring the outlets in the middle of the room if partitions were run to the center of each of the piers. Insertion plugs were placed in the baseboard and so located that each office would be sure to have a plug connection. The arrangement of the lights in the hall was very simple, one outlet being placed at the entrance, one opposite the elevators, one opposite the stairs and three between the entrance and the elevators. A single ceiling outlet was also located in the center of the toilet room, as shown.

As to the number of the lights for general lighting at the various outlets, the office walls being white and the lighting direct, the number of lights was based on allowing one (16-c.p.) lamp to about 600 to 800 cu. ft. This allowance, of course, does not include the base plugs, which, inasmuch as they are intended to serve for purely local lighting on desks and tables, would not contribute to any considerable extent to the general lighting of the offices. With this allowance and with the number and arrangement of lights shown on the plan (Fig. 2), the outlets in the offices vary from three to five lights apiece. The outlet in the toilet room serves for one light only. It might be stated here that the space on the left side of the building (as you enter) was rented out after the wiring was started. Owing to a peculiar arrangement of the space it was necessary to shift two of the ceiling outlets slightly and to add two floor outlets for lights on a banking counter in the center of the room; otherwise the outlets remained substantially as originally located.

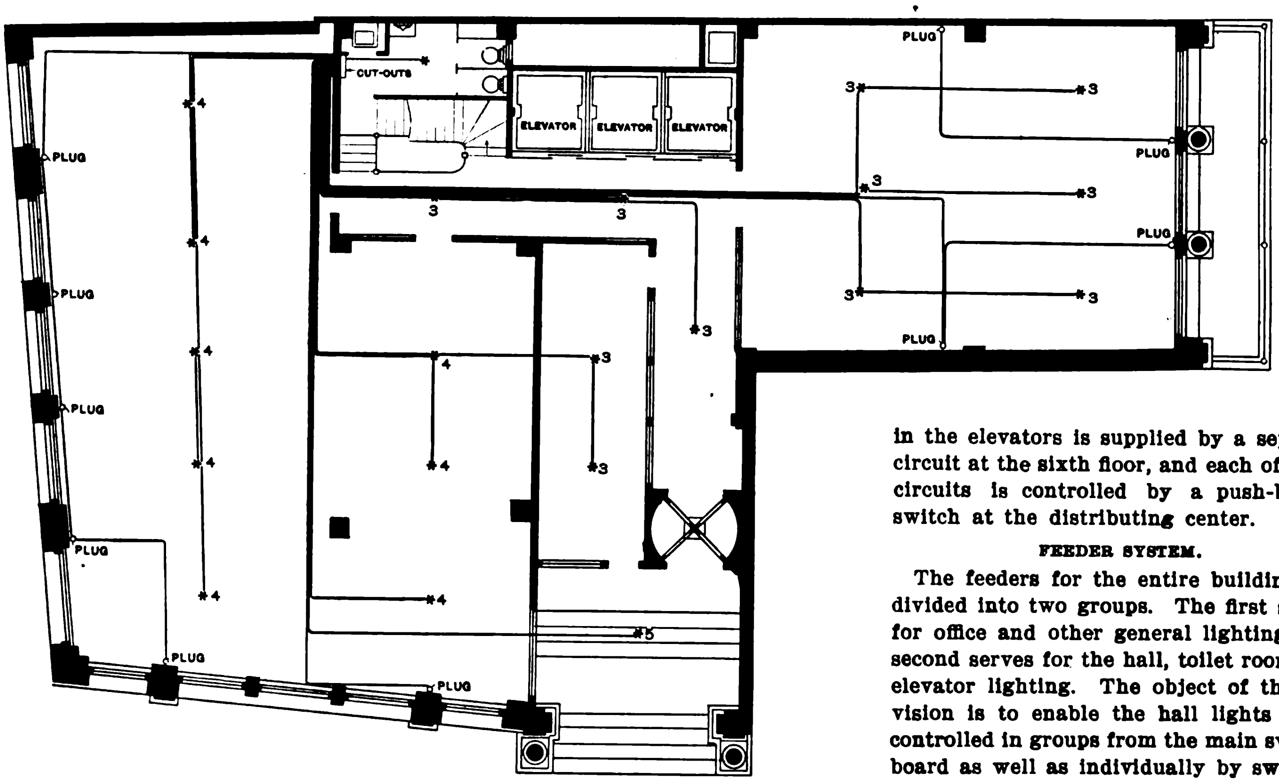

FIG. 2.—FIRST-FLOOR PLAN.

The outlets on the upper floors, from the second to the eleventh inclusive, were located practically at the same points on all floors. (See Fig. 3.) As these floors are entirely for offices, it was a comparatively simple matter to locate the outlets. They were accordingly located as shown on the plan. Plugs were also located in the baseboard in each office. On the same basis of allowance of cubic volume per lamp that was assumed on the first floor, the various outlets (with one exception) serve for three lights each. The four outlets in the hall are for two lights each, and the one in the toilet room is for one light. It will also be noticed that there is a one-light outlet shown in each of the elevators on this plan.

BRANCH CIRCUITS.

The question of the branch circuit wiring is next to be considered. The connections and arrangement of the outlets on the various branch circuits are shown in all three illustrations. The branch circuit wires are indicated by solid lines extending from the box containing the various fuses to the outlets. With the exception of the cellar, all the branch circuits serving ceiling outlets were run under the flooring of the story above. All the circuits for the plug outlets were run under the flooring of the same story on which the plugs were located. The branch circuits for the cellar outlets were run exposed on the walls and ceilings of cellar. In the cellar it will be noticed that the branch circuits, as a rule, do not supply more than four lights each, and sometimes even less. The reason for this is that, owing to rearrangement of the machinery, valves, etc., and also to the introduction of new machinery and appliances, it is frequently necessary to provide new outlets at various points. Ample provision for future extensions was therefore made on these circuits. The branch circuits of the cellar wiring were all supplied from a point at about the center of the cellar; the center of distribution on all the other floors was located in the toilet room. In the offices on the first floor the number of lights connected to each branch circuit varied between four and eight.

On the upper floors each circuit (with one exception at each floor) supplies two outlets for a total of six lights. In all cases each hall light was supplied by a separate circuit from the center of distribution and controlled by a separate push-button switch. The lights in the various offices are not controlled by switches but are turned on and off at the key sockets on the fixtures. Each of the outlets in the elevators is supplied by a separate circuit at the sixth floor, and each of these circuits is controlled by a push-button switch at the distributing center.

FEEDER SYSTEM.

The feeders for the entire building are divided into two groups. The first serves for office and other general lighting; the second serves for the hall, toilet room and elevator lighting. The object of this division is to enable the hall lights to be controlled in groups from the main switchboard as well as individually by switches from the distributing centers. The hall branch circuits, although originating at the same center of distribution as the office branch circuits, are supplied by separate feeders from those supplying the office lights. As will be seen from the feeder diagram shown in Fig. 4, there are four feeders for general lighting and two feeders for hall lighting. As there are no hall lights in the cellar, there is but one feeder serving the lights there; this feeder does not extend to any other floor, but supplies the cellar only. The lighting requirements in the cellar are peculiar and different from those on any of the other floors, which accounts for its being supplied by a distinct feeder.

The general lights on the basement and

first floor are supplied by a feeder to the center of distribution for the basement floor, and this feeder is extended by a sub-feeder to the center of distribution for the first floor. The offices on the upper floors are divided into two groups, each group consisting of five floors; two feeders supply them, one to each group. As will be seen in Fig. 4, each feeder connects with the center of distribution at the middle point of the group, and is extended up and down in each case to the two centers of distribution above and the two below the point of feeding. This method of feeding tends to equalize the voltage at the lamps on all floors. The hall lights of the basement and first floor are supplied in precisely the same manner as the general lights of those floors, viz., by a feeder which connects with the distributing center at that floor, and which is extended by a sub-feeder supplying the center of distribution for the hall lights at the first floor. This feeder was not extended further to the upper floors for the reason that these being the entrance floors, light might be required here at times when it might not be needed on the upper floors.

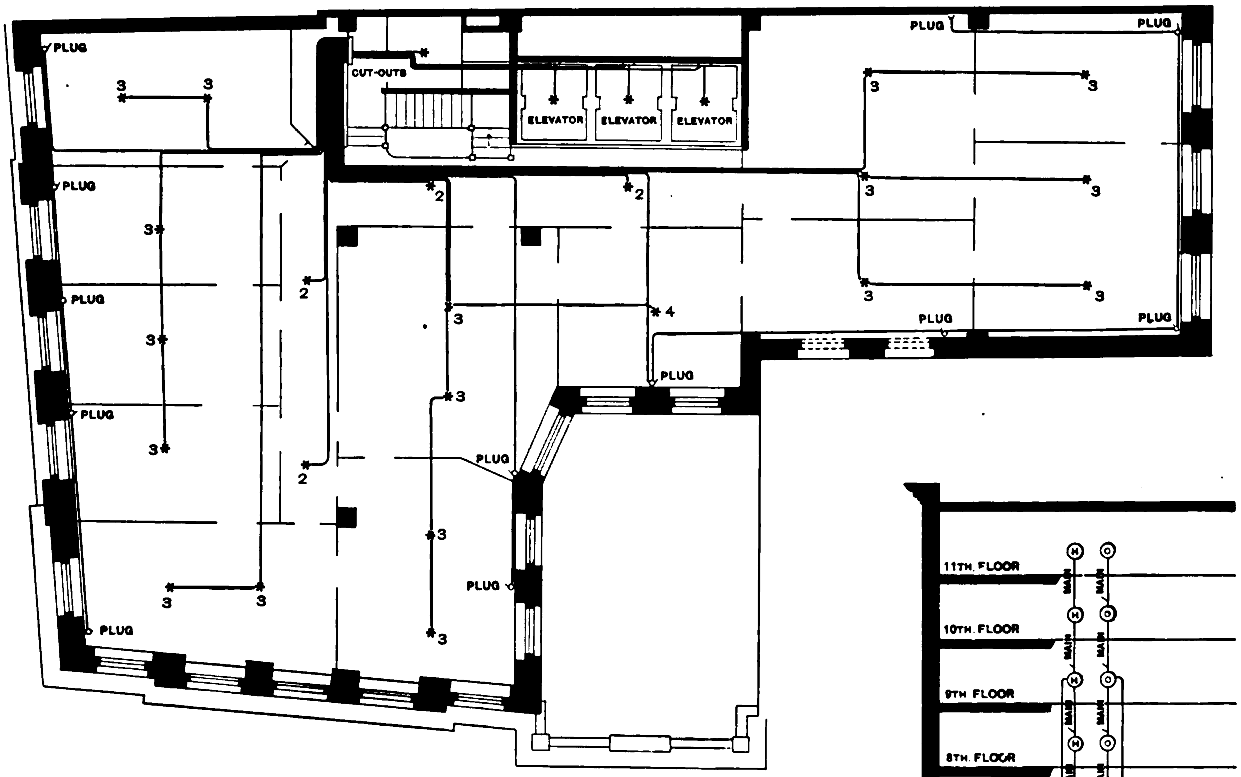

FIG. 3.—PLAN OF SECOND TO ELEVENTH FLOORS.

The hall lights of the upper floors (from the second to the tenth floor inclusive) are supplied by a single feeder. This feeder connects with the center of hall-light distribution at the fourth floor; from this point the feeder is extended up and down by sub-feeders to the centers of distribution at the two floors above and below, as shown in Fig. 4; each sub-feeder is also extended by a supplementary feeder to the center of distribution at the ninth floor, which in turn is extended up and down two stories in the same manner as the original feeder. This method of feeding was adopted because the number of hall lights was not sufficient to require two separate feeders for the upper floors. All the feeders start from the main switchboard in the cellar, and are run in conduits exposed on the ceiling of the cellar. The feeders were designed for the three-wire system, each feeder consisting of three wires, the middle wire double the size of either of the outside wires to permit "doubling up" and operating as a two-wire system.

CONDUITS AND OUTLET BOXES.

The conduits used are of iron pipe having the usual insulating paper lining. One conduit was used for the two wires in the case of the branch circuits, but a separate conduit was used for each of the conductors for the feeders and mains. Outlet boxes were used at all of the outlets. These boxes are of cast iron lined with porcelain enamel. Each box was designed and cast with the proper number and arrangement of openings for the particular place where it was used.

CUT-OUT PANELS.

Slate cut-out panels are located at the thirteen centers of distribution throughout the building. Each panel carries the usual bus-bars, fuses, lugs, etc., for making connections between the feeders or mains and the branch circuits. At all floors except the cellar, each panel carries two groups of cut-outs, one of which serves for the office lighting and the other for the hall lighting. A knife-blade switch is inserted at the origin of each of the mains on the slate panel. The branch-circuit fuses are of the removable fuse-holder type, similar to those described in a previous article of this series.

The cut-out panels or tablet boards are placed in the inner compartment of a double-wall cabinet. The inner compartment is lined with slate. The space between the inside and outside walls of the box is utilized for arranging the branch-circuit wires so as to bring them opposite the proper terminals on the bus-bars on the panel board. The push-button switches at the origin of the circuits for the hall lights are placed in a separate compartment at the upper part of the cut-out cabinets.

GENERAL.

The wires are, of course, rubber covered, the rubber being in two layers. The thickness of the rubber wall is about 3/64 in. on the No. 14 (B. & S. G.) wire for the branch circuits, and increased proportionately in the larger sizes. The wires are double-braided throughout. The cur-

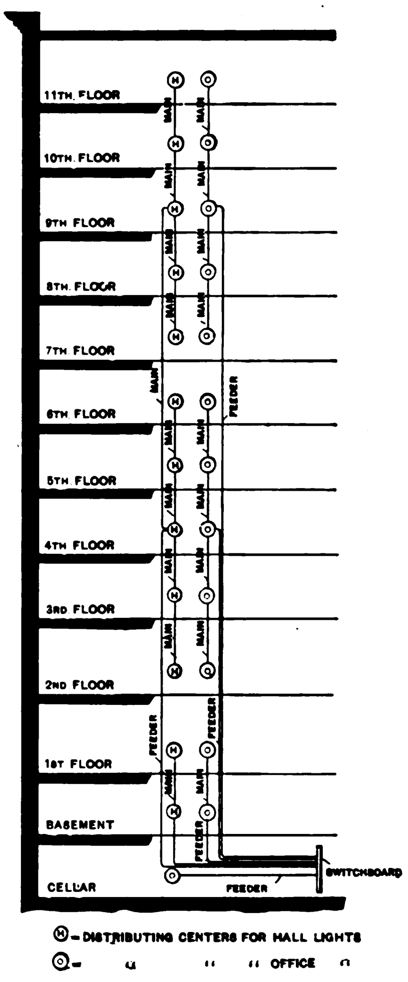

FIG. 4.—FEEDER SYSTEM.

rent supply for the building is at present obtained from the generating plant in the cellar. This plant consists of two 25-kw. dynamos direct-driven by two high-speed engines. The three leads from each dynamo run underground to the switchboard. These leads consist of rubber-covered and braided conductors, in iron-armored conduits.

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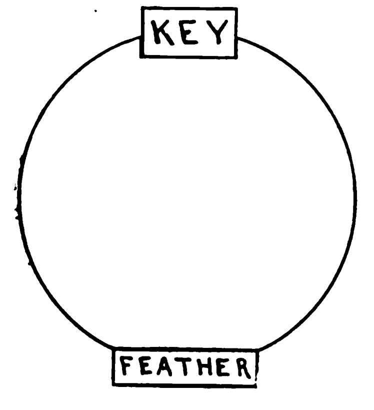
KEYS AND FEATHERS FOR SHAFTING.

Anyone having occasion to construct apparatus in which a shaft is employed will find the accompanying table of great convenience. Although the table gives sizes for feathers to be used with shafting up to 8 ins. diameter, this does not indicate that the use of feathers in such large work is good practice. In cases where circumstances may compel the use of a feather, the dimensions given may be followed, but it is always preferable to use a key. The keyway depth is measured at the sides of the slot, of course. The sketch herewith shows a 1½-in. shaft with key and feather of the dimensions specified by the table. The engraving is actual size.

Shaft Diam.	Keyway Depth.	Key.		Feather.	
		Width.	Thickness.	Width.	Thickness.
1	1/16	⅜	3/16	½	⅛
1⅛	1/16	7/16	7/32	9/16	5/32
1¼	1/16	7/16	7/32	⅝	5/32
1⅜	3/32	½	¼	11/16	3/16
1½	3/32	½	¼	¾	3/16
1⅝	3/32	9/16	9/32	13/16	7/32
1¾	3/32	9/16	9/32	⅞	7/32
1⅞	⅛	⅝	5/16	15/16	¼
2	⅛	⅝	5/16	1	¼
2¼	⅛	11/16	11/32	1⅛	9/32
2½	⅛	¾	⅜	1¼	5/16
2¾	5/32	13/16	13/32	1⅜	11/32
3	5/32	⅞	7/16	1½	⅜
3¼	3/16	15/16	15/32	1⅝	13/32
3½	3/16	1	½	1¾	7/16
3¾	3/16	1 1/16	17/32	1⅞	15/32
4	3/16	1⅛	9/16	2	½
4½	¼	1¼	⅝	2¼	9/16
5	¼	1⅜	11/16	2½	⅝
5½	¼	1½	¾	2¾	11/16
6	5/16	1⅝	13/16	3	¾
6½	5/16	1¾	⅞	3¼	13/16
7	5/16	1⅞	15/16	3½	⅞
7½	⅜	2	1	3¾	15/16
8	⅜	2⅛	1 1/16	4	1
9	7/16	2⅜	1 3/16	....	....
10	½	2⅝	1 5/16	....	....
11	9/16	2⅞	1 7/16	....	....
12	⅝	3⅛	1 9/16	....	....



1½-IN. SHAFT WITH KEY AND FEATHER.

HYDRAULIC DAMPER REGULATORS.

BY JAMES F. HOBART.

In a good many otherwise well-equipped steam plants the only damper regulating apparatus is a chain or cord stretched between the damper lever and a row of nails projecting from a convenient post. All the regulating that is done—and that is never much—is effected by hand, the chain being attached to one or the other of the nails according as the fireman thinks there is need, or as he "has time" to make the adjustment. That there is a good deal of unnecessary coal burned in this manner goes without saying; the method is very little better than no method at all. Even the obsolete direct-pressure regulator is far better than the nail-and-chain arrangement.

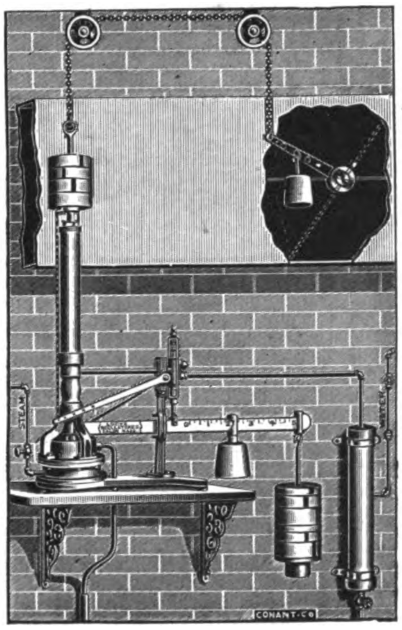


FIG. 1.—LOCKE REGULATOR.

The great problem of close damper regulation was solved by the introduction of the hydraulic damper regulator. In this device a diaphragm is actuated by steam pressure so as to operate a delicately balanced water valve. There is little or no work for the diaphragm to do, so that it responds at once to the slightest variation of pressure; in fact a regulator of this class will act before the steam gauges can show the variation.

Fig. 1 represents the well-known Locke damper regulator, made by The Locke Regulator Company of Salem, Mass. It will be noted that the crude diaphragm and weight affair has been replaced by a very accurate-looking weighing machine. The scale beam and weights "weigh" the steam pressure in the boiler, and when that pressure varies ever so little, the valve shown above the beam opens and admits water under pressure to the operating cylinder shown above the diaphragm mechanism. This water pressure raises a piston in the working cylinder to which the chain is attached, permitting the weight at the damper to fall and choke the smoke passage. When the steam pressure falls the diaphragm closes the inlet and opens an outlet valve, allowing water to be discharged from the cylinder; the weights on top of the piston are heavier than the small one at the damper lever, so that the piston falls and the smoke passage is opened full again.

But another operation is necessary in all dampers of this class. It must be so arranged that when the damper operating piston has started to move upward or downward it will not go on to the end of the cylinder, thus opening or closing the damper fully at the smallest variation of steam pressure. This checking is effected by means of the lever shown above the scale beam which forms a mechanical connection between the water valve and the upper end of the water-piston rod. By means of this connection the water valve is closed again as soon as the piston has moved a certain distance, which depends on the amount of water admitted, or the amount the diaphragm rises before the water acts upon the damper piston. If the steam variation is very slight, and the water piston only receives a small amount of water, the valve will be closed very quickly after the starting of the piston. But if there is a considerable movement of the diaphragm, due to a considerable fluctuation of steam, then the damper movement will be greater. Usually, there is only a very small movement of the water piston, the special device closing off

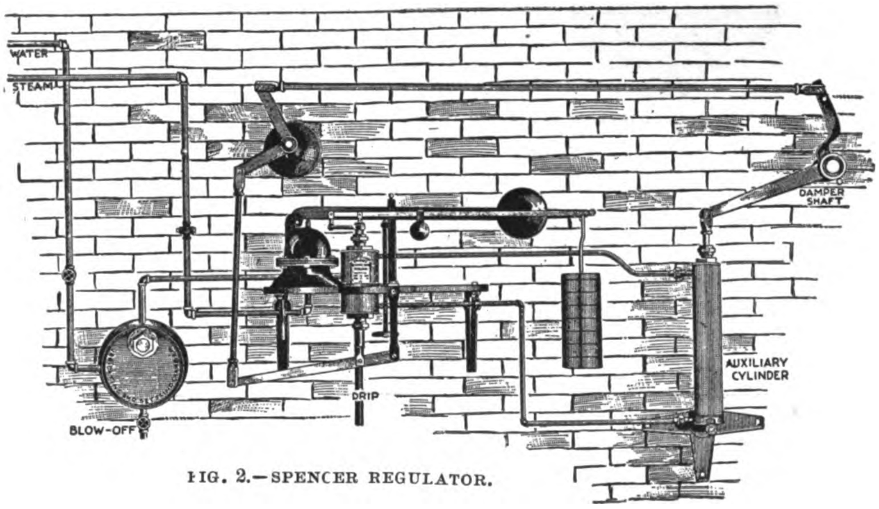


FIG. 2.—SPENCER REGULATOR.

the water pressure quickly, so that when there is even a considerable movement of the damper necessary, it travels by a series of steps, rather than by one continuous movement.

Another well-known form of damper regulator is illustrated by Fig. 2. This is the Spencer regulator, marketed by G. G. Stillman, of Boston, Mass. This appliance is also an elaborate steam-weighing device, and controls the damper by means of a hydraulic cylinder. There is an auxiliary cylinder in addition to the regular hydraulic cylinder for the purpose of moving extra heavy dampers, and as that cylinder can be made of any length and diameter, there is no limit to the amount of work it can be made to do. This cylinder is also controlled by the same valve which controls admission to the regular cylinder. There is also another attachment, consisting of a settling tank or chamber, in which is precipitated any **sediment which may be contained in the water and perhaps clog the valve. In case any foreign matter should get into the cylinder and cause the piston to move hard, a bit of hard soap is placed in the upper part of the chamber. Slowly dissolving, the soap forms a lubricant for the piston and cylinder. Sediment which collects in the lower chamber is readily blown out by a valve provided at the bottom of the chamber for that purpose. Where the load is light, as in ordinary cases, the auxiliary cylinder is not necessary, and is dispensed with.**

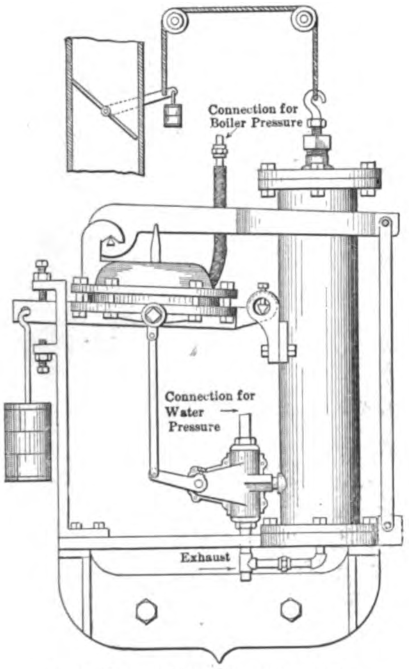


FIG. 5.—CLIMAX REGULATOR.

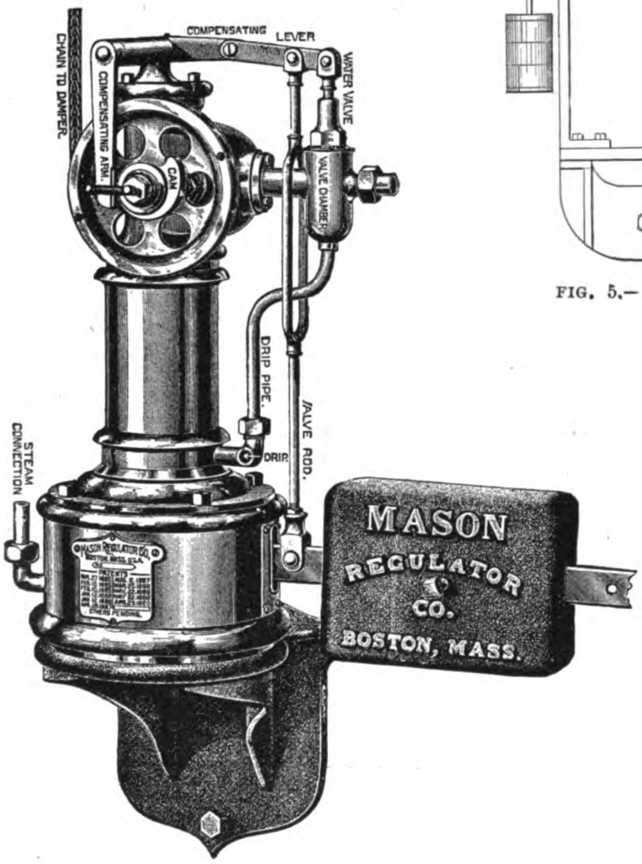


FIG. 3.—MASON REGULATOR.

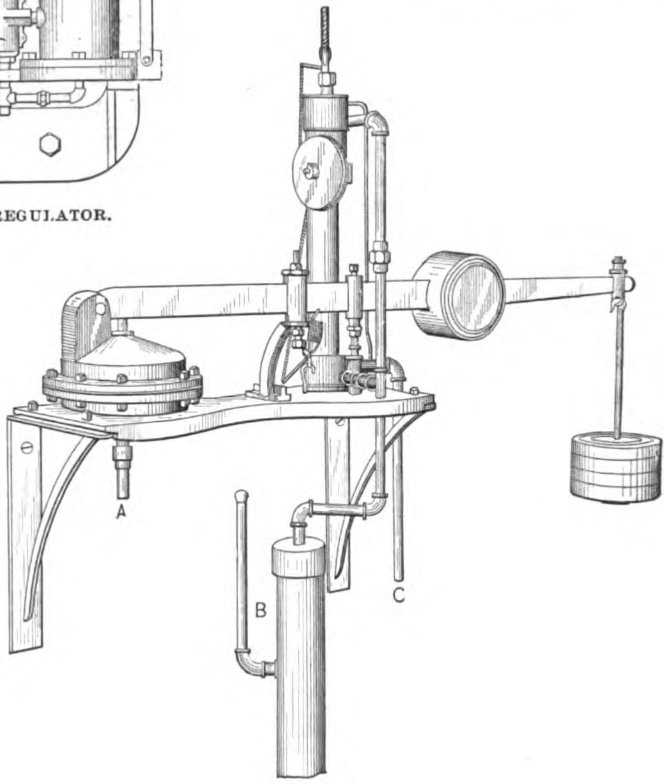


FIG. 4.—LAWRENCE REGULATOR.

Another excellent hydraulic regulator is the Mason, illustrated by Fig. 3, and built by the Mason Regulator Company, Boston, Mass. It embodies novel compensating devices for preventing the valve from going either full open or full shut when the diaphragm opens the steam valve a little. There is the usual steam diaphragm, but the water and valve mechanism is mounted above, using the diaphragm enclosure as a base and thereby making a very compact and fine-looking instrument. The compensating device consists of a cam attached to the wheel upon which the damper actuating chain is wound up when the damper closes. The wheel is really only a rotary lever, and the cam furnishes a varying fulcrum for the valve mechanism to work from when the movement of the water-piston is to be checked.

It is not generally understood by engineers that the water pressure from a boiler may be used to operate these damper regulators, but such is the case. Where there is no city service pressure available, it is only necessary to connect the water cylinder with the boiler below the water lines, while the diaphragm chamber is connected above that line. Care must be taken to put in enough pipe so that the water may become cool during its journey from the boiler to the cylinder, as hot water might cause the piston to bind or stick and work irregularly.

Another type of hydraulic regulator, shown by Fig. 4, is the Lawrence damper regulator, made by The Watts Regulator Company, Lawrence, Mass. This appliance contains all the refinements found in other regulators. There is the high-grade weighing beam, the water-settling chamber and the valve adjustments for preventing a wide movement of the water piston upon small variations of the steam pressure. The wheel or cam arrangement enters as a factor in the regulation of this damper and the adjustment attachments are placed directly upon the scale-beam.

The very compact regulator shown by Fig. 5 is known as the Climax, and is made by Kieley & Mueller, New York. A peculiarity of this regulator is that the diaphragm remains approximately stationary while the casing moves up and **down according to the variations of steam pressure. There is, however, some movement of the diaphragm, but it is relative, not direct. By means of levers resting upon knife edges the entire diaphragm mechanism is delicately connected to the water cylinder, which forms the main portion of the instrument. Thus the movement of the diaphragm case causes movement of the water valve which controls the damper direct. There will be noted a couple of screw adjustments above and below the diaphragm-case lever, by means of which the movement of the lever can be controlled as desired. It is a peculiarity of this regulator that the water piston is used to open the damper, not to** close it. The weight attached directly to the damper lever does that, and when the water enters the cylinder it only has to overcome the action of the weight. In closing the damper, some of the water is let out of the cylinder by the diaphragm valve, causing the damper to be closed a little, and very slowly. Nearly all cases will be properly controlled by the above-mentioned arrangement, but where necessary, a graduating attachment is furnished which controls the movement of the water piston, as described in connection with the other damper regulators.

Lessons in Practical Electricity

MAGNETIC LEAKAGE IN TRANSFORMERS.

As stated in general terms in a previous lesson, it is impossible to prevent entirely the leakage of magnetic lines of force between the two windings. It is almost impossible to predetermine by calculation the leakage coefficient of a transformer, but the effect can be readily measured. The effect of leakage is the same as though inductances were inserted in the primary and secondary circuits; that is, there is a choking effect which increases the secondary drop. Reference to Fig. 24 will help to make this clear. The dotted lines indicate leakage flux, or lines that encircle only one of the windings. It is evident that the flux which encircles the primary coil alone has the same effect upon that coil that it would have if the secondary winding did not exist—it induces a back e.m.f. in the primary winding exactly proportional to the number of lines of force that leak across between the two windings. Similarly, the flux encircling the secondary coil induces a back e.m.f. in that coil.

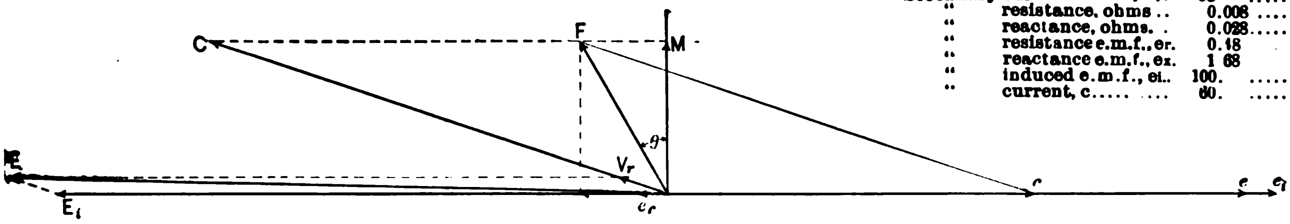


FIG. 29.—HYPOTHETICAL TRANSFORMER DIAGRAM, ASSUMING NO MAGNETIC LEAKAGE.

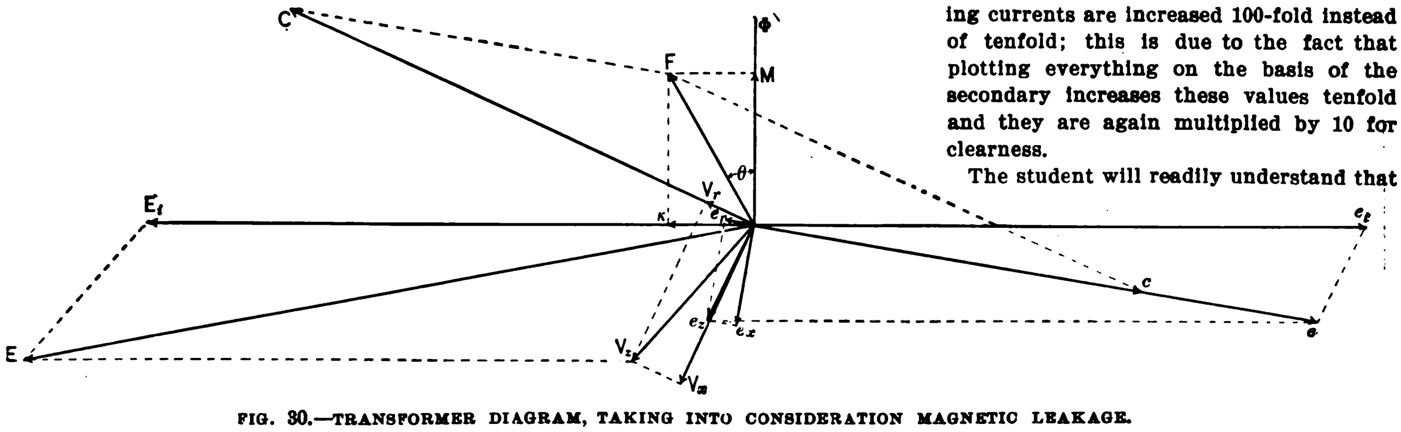


FIG. 30.—TRANSFORMER DIAGRAM, TAKING INTO CONSIDERATION MAGNETIC LEAKAGE.

The leakage flux around the primary winding is created by the primary ampere-turns, and that around the secondary by the secondary ampere-turns. As the primary and secondary currents flow in opposite directions, the direction of the leakage fluxes between the coils agrees, so that each coil tends to aggravate the leakage around the other. The leakage may be somewhat modified by the shape and arrangement of the windings. A long thin coil, as shown in Fig. 25, will show less leakage than a short, thick one, as shown in Fig. 26, when the coils are not iron-clad. In an iron-clad or shell-type transformer minimum leakage is obtained by arranging the windings so that a line drawn from side to side of the "window," along the shortest dimension, will pass through both coils. This arrangement is shown in Fig. 27. If the coils were arranged as in Fig. 28, the leakage would be greater.

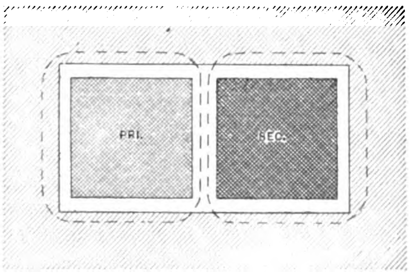


FIG. 24.

The reactive e.m.fs. induced in the two windings by the leakage flux are fortunately not squarely opposed to the primary and secondary e.m.fs., and their effect on the regulation of the transformer is consequently not in proportion to their magnitude. The phase of each reactive e.m.f. is in quadrature with that of the current that produces it, and lags behind it, of course. Therefore, the reactive e.m.f. of the primary winding lags 90° behind the primary current phase, and the reactive e.m.f. of the secondary winding lags 90° behind the secondary current. These relations are maintained regardless of the magnitude or character of the load. Fig. 29 is a vector diagram showing the phase relations of 6-kw. core-type transformer with the smaller values exaggerated tenfold in order to make them distinguishable. The primary figures have been reduced to a level with the secondary, so that the primary and secondary induced e.m.fs. shall be equal.

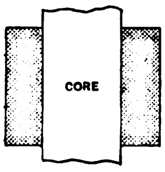


FIG. 25.

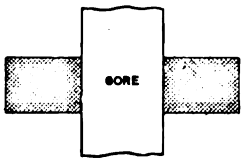


FIG. 26.

The actual data and the values that are plotted are as follows:

AT 133 CYCLES.

	Actual.	Reduc'd to secondary.	Plotted.
Core cross-section, sq. ins. ...	16	......	......
Length of magnetic path, ins.	30	......	......
Volume of core iron, cu. ins..	480	......	......
Density per sq. in., B	18,400	......	......
Primary turns	580	...	......
" resistance, ohms....	1.45	......	......
" reactance, ohms ..	4.85	......	......
" resistance drop, Vr.	8.75	0.875	8.75
" reactance drop, Vx..	29.5	2 95	29.5
" induced e.m.f., Et...	1,000	100.	100.
" current, C...........	6+	60.	
Secondary turns . ..	58	......	......
" resistance, ohms ..	0.008	......	......
" reactance, ohms. .	0.028	......	......
" resistance e.m.f., er.	0.48		4.8
" reactance e.m.f., ex.	1 68		16.8
" induced e.m.f., et..	100.	......	100.
" current, c.....	60.	......	60.
Magnetizing current, M......	0.25	2.5	25.
Core-loss current, κ	0.144	1.44	14.4
Exciting current, F....	0.288	2.885	28.85
Core-loss angle, θ...........	30°	......	30°

It will be noticed that the primary resistance and reactance drops are plotted at actual value. The explanation is that reducing all primary values to the secondary basis reduces these tenfold and they are then multiplied tenfold for clearness, as above explained. It will also be noticed that the magnetizing, core-loss and exciting currents are increased 100-fold instead of tenfold; this is due to the fact that plotting everything on the basis of the secondary increases these values tenfold and they are again multiplied by 10 for clearness.

The student will readily understand that increasing the internal losses of the transformer tenfold has greatly exaggerated the drop due to these losses as well as the difference in phase between the primary e.m.f., E, and the current, C, and the difference between the secondary delivered e.m.f., e, and the current, c. However, a comparison of Fig. 29 with Fig. 30 will afford an idea of the extent to which magnetic leakage affects the drop. The former diagram shows what the phase relations would be if there were no leakage. The comparison is given below:

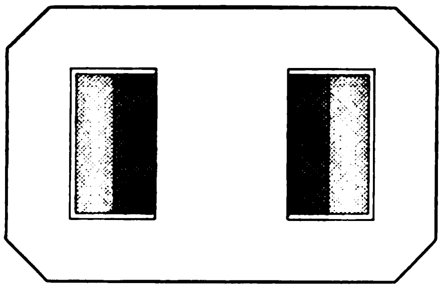


FIG. 27.

	Fig. 30.	Fig. 29.
Induced e.m.fs......	100	100
Primary impressed e.m.f....	122	108
Secondary delivered e.m.f...	94	95.2
Total drop	28	13.2
Increase of drop by leakage	115 per cent	

The reactance specified in the first table is due to magnetic leakage only; multiplying the reactance by the current in the winding gives the reactive e.m.f. or drop due to leakage.

In Fig. 29 the magnetizing current is shown as identical with the magnetizing current in Fig. 30, but if magnetic leakage could be eliminated, it would be somewhat less than when leakage is present. However, the diagram is presented only to illustrate the effect of leakage, so that hair-splitting is not necessary. Moreover, the lines representing losses are exaggerated to ten times their actual value; if the correct lengths were plotted the difference in magnetizing current due to magnetic leakage would be scarcely discernible.

It will be excellent practice for the reader to construct a large diagram, using the actual constants of the transformer, with the primary values reduced to the secondary basis, as given by the table. It will also be of advantage to compute from the actual values given what the impedance and impedance drop are, primary and secondary, and what the permeability of the core iron is. Also, what the copper and iron losses are in watts and the efficiency of the transformer at full load. These diagrams and calculations may be submitted to the editor of this paper, if the reader wishes, for comment or correction—privately, of course.

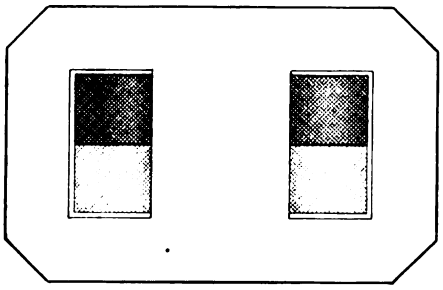


FIG. 28.

Letters on Practical Subjects

Queer Experimental Results.

To the Editor, American Electrician;

Sir:—From a feeder on an electric railway, which has a ground return, five 16-c.p. 110-volt incandescent lamps were connected in series with each other and with a 110-volt fan motor; the motor ran nearly up to speed. The line voltage was 550.

Again, two series of five lamps each were placed in parallel, and between these and the ground, one of the same kind of lamps was connected. When the current was switched on, all the lamps apparently burned at full candle-power, and the single lamp did not seem any brighter than the others. Can some one offer an explanation? W. E. Howard.

Alexandria, Va.

Low Voltage on Street Railways.

To the Editor, American Electrician;

Sir:—In a recent paper the question, "Why is it injurious to run street railway motors on low voltage?" was asked, and the answer was in effect that as the volts times the amperes represent the work done, it would require a greater number of amperes at low voltage than at high voltage to do the same work. That this statement is true I have no doubt, but does it answer the question? Is there much difference in the operation of street railway motors and simple shunt motors when working up to full speed or on full line pressure? It has been my experience with shunt motors, when the voltage drops the speed drops, thereby reducing the work done; but I have never seen the amperes rise on a reduction of voltage.

Chicago, Ills. Joe M. Davis.

[Undoubtedly, the answer was badly expressed. When the e.m.f. drops, the speed of the car decreases, but this fact causes the motorman to use higher controller notches than would otherwise be used to maintain his schedule and it is quite possible for the average current through the motors to be carried higher than would be the case with normal voltage. Moreover, where there are grades, the low voltage prolongs the climb, and the duration of load is a serious factor in the heating of railway motors. A series motor acts very much like a shunt motor when the iron in its magnetic circuit is highly saturated, but not otherwise.—Editor.].

An Autotransformer Problem.

To the Editor, American Electrician;

Sir:—The accompanying sketches represent two methods of connecting up an autotransformer. Fig. 1 shows the supply circuit tapped in half-way of the winding and the work circuit fed from the extreme ends. Fig. 2 shows these connections interchanged. It is well known, of course, that the voltage relations are as indicated on the diagrams, but it is not so well known why they are so. It may interest some readers to reason out what the internal actions are in such an apparatus. In Fig. 1, suppose the load to be 2 amperes; how much current flows through A and how much through B? And is the direction of the current in A at a given instant the same as that in B or opposite to it? In Fig. 2, assume a load of 4 amperes, and explain the relations between the two halves, A and B, of the winding. Ralph J. Patterson.

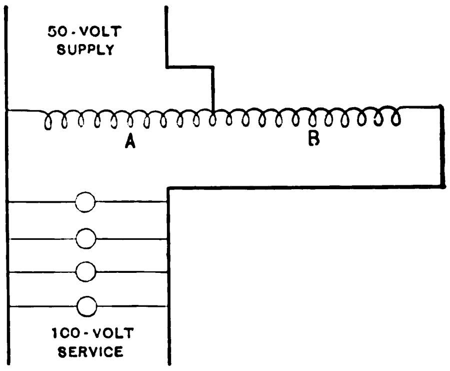


FIG. 1.—AUTOTRANSFORMER PROBLEM.

Woburn, Mass.

Peculiar Motor Action.

To the Editor, American Electrician;

Sir:—My attention was recently called to the peculiar action of a 500-volt 15-h.p. motor. It was a four-pole shunt-wound machine with a wave-wound drum armature, and ran at 750 r.p.m. When first installed it was subjected to a test run of ten hours under full load. During the test there was practically no sparking or heating at the commutator, but at the end of the test all of the commutator bars except six were blackened. The six bars referred to were as bright as before the motor was connected up; three of these were diametrically opposite the other three, and the three coils connected to these six bars were in one slot, the armature winding being arranged three coils to a slot. I would appreciate it if any of your readers can suggest a reason why six of the bars of the commutator remained bright while all of the others were darkened.

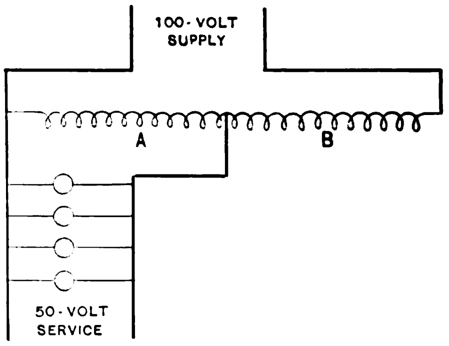


FIG. 2.—AUTOTRANSFORMER PROBLEM.

Carl J. Fechheimer.

Cincinnati, Ohio.

Electrical Catechism

524. Is the amount of current carried by a conductor limited only by the drop?

No; there is a limit imposed by the heating effect or rise of temperature produced by the current.

525. How is the safe carrying capacity of a conductor determined?

For "wiring" purposes—that is, for use as conductors for electric light or power—the table of the National Electrical Code applies. The size of wire needed in other situations depends so largely upon circumstances that no definite rule can be laid down. The rule in the navy is 1000 amperes per square inch, or 1273 circular mils per ampere. The moving parts of dynamos and motors have the copper wire proportioned for about 350 to 700 circular mils per ampere, while the stationary coils have 850 to 1400 circular mils per ampere. The conditions of ventilation and allowable rise of temperature vary so widely that no definite general rule can be laid down.

526. What is the rule of the National Electrical Code relating to currents and sizes of wire?

Conductors must be of practically pure copper, or if of other material must be large enough to secure equal conductivity. No wire must carry more than the current indicated in the following table:

B. & S. G.	Rubber covered wires.	Weather-proof wires.
18	3	5
16	6	8
14	12	16
12	17	23
10	24	32
8	33	46
6	46	65
5	54	77
4	65	92
3	76	110
2	90	131
1	107	156
0	127	185
00	150	220
000	177	262
0000	210	312

The current-carrying capacity of Nos. 18 and 16 is given, but no smaller than fourteen is to be used except in fixtures. The choice between weatherproof and rubber-covered wires depends upon circumstances. As a general rule rubber-covered wire is required for use inside of buildings.

527. What governs the rise of temperature in a conductor carrying a current?

Whenever current passes through a conductor, more or less electrical energy is unavoidably changed into heat energy (see No. 553), and the temperature rises until the heat is lost by the conductor at the same rate at which it is received from the current.

528. What becomes of the heat liberated in a conductor?

It is carried away by conduction, by convection and by radiation. Some of it is carried away by conduction along the wire to a place where the temperature may be lower. Some of it is carried away by convection currents of air. Some is carried away by radiation, a process similar to that which one feels the direct heat from a fire or from the sun. The amount carried off by convection and by radiation depends upon the difference between the temperature of the conductor and that of the surrounding objects, upon the character of the surface of the conductor and upon the freedom of circulation of air.

529. How can excessive heating of conductors be avoided?

By proper design in the first place, making the conductors amply large for the current to be carried. In the next place each circuit should be provided with suitable safety devices, such as fuses or circuit-breakers, that will open the circuit when the current exceeds a safe amount.

530. What is a circuit-breaker?

A circuit-breaker is an electro-magnetic device for opening an electric circuit when the current varies beyond certain desired limits. Generally it is arranged to open the circuit when the current exceeds a certain amount, although for some purposes arranged to open the circuit when the current falls below a fixed amount. It is operated by an electro-magnet whose core is attracted so as to trip a release trigger or detent and allow a spring to open the switch when the current exceeds the limit set. Circuit-breakers are frequently used instead of or to supplement fuses with dynamos and motors.

531. What is a fuse?

There are two entirely different devices called by the same name and based upon the heating effect of the current, one being used for firing explosives. The safety fuse referred to in connection with insurance rules is a special part of an electric circuit designed to carry the ordinary amount of current but to melt and open the circuit in case the current becomes great enough to heat any other part of the circuit beyond a safe temperature. The fuse is made of such material and dimensions that its resistance is considerably higher than an equal length of the rest of the circuit. Since the heat developed equals the product of the resistance by the square of the current, the fuse is continually at a higher temperature than other parts of the circuit (except of course lamps and other heating devices); as its melting temperature is generally comparatively low, an increase of current above that for which the circuit is designed will raise the fuse to its melting temperature so that it will fall away and open the circuit.

532. What other names are given to fuses?

They are called cut-outs, safety catches, safety fuses, safeties, fuse plugs. The fusible part is sometimes called a fuse link, a fuse plug, a protector or sometimes a fusible.

533. What are the requirements of a fuse?

It should melt at a comparatively low temperature, so as not to endanger setting fire to surrounding substances. It should melt quietly, so as not to throw melted particles where they might cause damage. It should have hard terminals, so that the contact between it and the rest of the circuit shall continue firm. It should have a definite melting point that will not change with prolonged heating. It should be long enough so that an arc cannot be maintained between the terminals after the fuse is melted. It should be mounted upon a non-combustible, non-absorbtive base.

534. What substances are used for fuses?

The most common is an alloy of tin and lead, such as "half and half" solder. Bismuth is frequently added to the alloy to lower the melting point. Copper wire is sometimes used in exposed places where there is no danger from flying particles or from the high temperature of the fuse with normal current. Iron wire should not be used, since it burns when melted and is very liable to carry fire. Numerous "tested" fuses of more or less secret alloys are upon the market. Aluminum is coming into extensive use as a fuse metal.

535. What determines the current required to melt a fuse?

It depends upon the diameter, more current being required to melt a thick wire than a thin one; it depends upon the melting temperature of the material, some alloys melting at low temperatures; it depends upon the specific resistance of the fuse metal, also upon its temperature coefficient (that is, the amount the resistance changes with temperature), since the resistance determines the amount of heat developed by the passage of a given current; it depends upon the cooling effect of the terminals and therefore (within certain limits) upon the length of the fuse wire; it depends upon the conditions for dissipating heat by convection and radiation. The quickness with which a fuse will melt after the current has reached the limit depends upon the specific heat of the metal, that is, upon the number of heat units required to raise the temperature one degree, and also depends upon the latent heat, or the amount of heat that disappears in melting the substance. The current required to "blow" a fuse varies to some extent with age, as the heating in service results in oxidization and consequent weakening.

536. How are fuses rated?

Fuses are sometimes rated according to the number of amperes to be taken normally by the circuit they are to protect. For example, a ten-ampere fuse is supposed to protect a circuit whose regular current should not exceed ten amperes and to open the circuit if the current rises above say twelve amperes. It is also common to rate fuses according to the current they will certainly carry, for example, a ten-ampere fuse wire will carry ten amperes without melting, but how much more it will carry is not specified, and it may carry even twenty amperes before melting. The rules of the underwriters require that each fuse be stamped with about 80 per cent of the maximum current they can carry indefinitely, thus allowing about 25 per cent overload before the fuse melts.

Queries and Answers

IMPORTANT.—No attention will be given to inquiries which do not give the full name and address of the inquirer.

Is it regarded good practice to fuse the secondary of a transformer? (2). Please explain what takes place when a transformer is changed from a 60-cycle circuit to a 133-cycle circuit, or the reverse. C. J. D.

Yes. (2) Refer to the Lessons department in the September issue.

What is the best flux for soldering armature wires? (2). What is the best insulating compound to dip armature coils in before and after taping them? G. B. F.

Resin. (2) Either shellac varnish or P. & B. compound. The armature coil should be thoroughly painted, however, in preference to dipping.

How is the capacity of condensers in series computed? W. E. B.

Divide the capacity of one by the number in series; all must be of the same size. For example, three condensers of six microfarads each will have a capacity of two microfarads when connected in series, and 18 microfarads when grouped in multiple.

Please give 500-volt winding for the 3-h.p. motor described in the September issue. F. S.

Use No. 20 wire on the armature, putting in as many turns per coil as the space will allow, and use No. 28 wire on the fields, winding the coils three-quarters of an inch deep. The armature slots must be somewhat more heavily insulated than for 230 volts.

I have 45 cells of storage battery connected in series; what is the best rate of charging? (2). How far is it advisable to discharge the cells? W. G.

Measure the total surface of the positive plates in one cell and let the charging current for the 45 cells in series be from 6 to 8 amperes per square foot of positive plate surface in the one cell. (2) The 45 cells should not be discharged below 82 volts.

Is it true that magnetism will not pass through brass? (2). What kind of battery is most suitable for operating a small induction coil? (3). Should a regulating switch be connected in the primary or the secondary of an induction coil? G. P. L.

No. (2). Any good dry battery will answer if the coil is not to be used long at a time. (3). A switch is not necessary; the best method is to slide the core in and out of the coil.

Would it be practical to reduce the diameter of the field ring of the motor described in the September issue, provided the ampere turns of the field cores are kept the same? R. L.

It would not be advisable to reduce the diameter for the reason that this would shorten the field coils and the radiating surface would be too small. The ampere-turns remain practically the same regardless of the length of the coils.

Please give me directions for figuring the horse-power from the pull at the end of a prony brake lever. E. F. W.

Multiply the length of the brake lever in feet by the pounds of pull at its end and by the revolutions of the engine per minute. Multiply the result by 19 and divide by 100,000; the answer will be the horse-power absorbed by the brake. In the shape of a formula this would be expressed as follows:

$$\frac{19 \times \text{r.p.m.} \times L \times \text{lbs.}}{100{,}000} = \text{horse-power.}$$

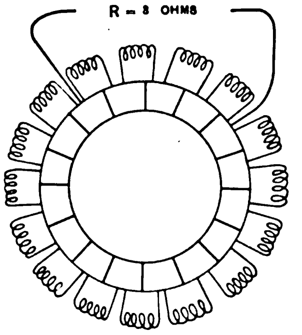
If it were possible to make a bulb of a substance as light as air and exhaust all the air from the interior of it would the bulb be lighter than the surrounding air and rise? (2). If hydrogen gas were introduced into a vessel which previously contained a perfect vacuum would it not fall to the bottom of the vessel? C. M. G.

Yes, the bulb would rise if any appreciable amount of air were withdrawn from it. (2) No; the gas would expand and fill the vessel.

I have a D-62 generator running in multiple with several others of a different type. The D-62 machine takes its share at full load but takes more than its share when the load drops. How can I remedy this? W. C. H.

Lengthen the resistance strip that shunts the series field of the D-62 machine and weaken its shunt field by means of the rheostat, making the adjustment little by little until the machine divides the load properly at full load and also at the average running load.

Suppose the joint resistance of a 16-coil armature measures 3 ohms with the testing wires applied as shown in the accompanying sketch, how can the resistance of a single coil be calculated? C. T. V.



The easiest method is to figure in conductance instead of resistance. The total resistance being 3 ohms, the conductance will be 1/3. The relative conductances of the two groups is inversely as their number, assuming that all of the coils are exactly alike; therefore, the twelve coils being three times the length of the four coils will have 1/3 the conductance of the latter, or ¼ of the total conductance. As the total conductance is 1/3 and the conductance of the twelve coils is ¼ of this, their conductance is 1/12; consequently, their resistance is 12/1 = 12 ohms, and the resistance of a single coil is 1/12 of this, or 1 ohm.

I have two compound-wound direct-connected dynamos which operate in parallel when necessary. The polarity of one of them has reversed so that I cannot operate the two in parallel. How can I change it back? J. W. M.

Remove the brushes from the holders of the reversed machine, bring the other machine up to full voltage and close the main switches of both machines; this will charge the field magnet of the reversed machine in the right direction. Then open the main switch of the idle machine, put its brushes in and put it to work.

The shunt resistance strips on the series field of a booster run dangerously hot. There are two 3-inch strips in parallel. Will not four strips of twice the length and the same cross-section give the same resistance and run cooler? W. C. H.

Approximately, but not precisely. The four 6-in. strips will have slightly less resistance because of their lower temperature. Make them 6¾ ins. long and adjust the effective length to give the proper results.

How is the candle power of arc and incandescent lamps figured, knowing the watts consumed? L. T.

The candle-power of an incandescent lamp cannot be figured accurately from the amount of current consumed unless the rating of the lamp is exact and the voltage normal. If you have the precise rating from the manufacturers and the voltage at the terminals of the lamp is normal, then the candle-power given will be equal to the total watts divided by the rating of the lamp. This is true of an incandescent lamp only when it is new, as it is impossible to determine precisely what its variation in efficiency will have been after it has been in service some time. The only reliable way to ascertain the candle-power of an incandescent lamp, and the only possible way to ascertain that of an arc lamp is to measure it by means of a photometer. The candle-power of an arc lamp cannot be figured from the applied watts.

If the armature of the four-kilowatt motor described in the May issue were to be used for an induction motor or generator, would the same windings and connections be all right? (2) Would the capacity be as great? (3) When used as a generator, excited by a synchronous motor or condensers, how many amperes would it take? (4) What determines the size of condensers for a certain capacity and how different are they for high and low voltage? C. S.

The four-kilowatt machine described in the May number cannot be used as an induction motor. A machine wound as described in the article is all right for use as a generator without any change. (2) It will be self-exciting and will give 80 volts as a single-phase alternator, 80 volts per phase as a two-phase machine, or 70 volts per phase as a three-phase alternator. (3) Generators are not excited by synchronous motors nor condensers. Condensers are only used in connection with highly inductive lines or apparatus to neutralize the self-induction of the lines or apparatus. (4) The size of a condenser to have a certain capacity is determined by the character of the insulation, technically known as the "dielectric," between the plates of a condenser. When the dielectric is made of paraffine paper the size of the sheet is given by the formula: $6500 \times t \times k =$ area of plates (on one side) in square feet. In this formula "t" is the thickness of the insulating sheet between the plates in fractions of an inch, and "k" is the capacity of the condenser in microfarads. The only difference between condensers built for high and low voltage is that the dielectric or insulating material must be of a better grade for high voltage.

A PHOTOMETER FOR SAME-CIRCUIT AND SEPARATE-CIRCUIT WORK.

The two recognized standard methods of incandescent electric lamp photometry are the same-circuit method, with both lamps simultaneousy governed by one resistance, and the separate-circuit method in which each lamp is separately controlled.

The same-circuit method is based on the fact that two absolutely identical lamps deliver absolutely identical illuminations at the same voltages. It is evident that if the voltage, candle-power, etc., of a lamp is known, another lamp which is exactly similar could also be properly rated at the same voltage and candle-power without regard to the actual candle-power the lamps are delivering or the voltage on which they are being operated at the time the comparison is made. For example, if a 16-c.p. 110-volt 3.1-watt lamp be compared with another lamp, the two having exactly the same voltage applied (105 volts, for instance) and the second lamp is found to deliver the same candles and to pass the same current at the reduced e.m.f., this second lamp will also be a 110-volt 16-c.p. 3.1-watt lamp.

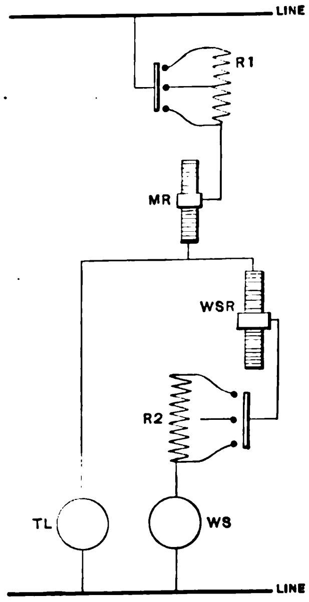


FIG. 1.—SAME-CIRCUIT CONNECTIONS.

From the above it follows that if two lamps deliver the same candles at normal voltage, when the two are subjected to voltages a given percentage above or below normal, the candle-power of the two lamps will maintain their same relation without regard to the actual voltage and actual candles. That is, a 110-volt 16-c.p. and a 55-volt 16-c.p. lamp, each reduced 4.8 per cent in voltage, will each deliver 12 candles. It is obvious, therefore, that in the same-circuit method it is necessary only that the percentage change in voltage on the lamps under comparison shall be the same.

The original same-circuit method* required a different working standard for every voltage and candle-power and if strict accuracy was to be maintained this working standard had to be rather carefully selected. If the candle-power of the working standard changed materially a new standard had to be procured. The Bryan-Marsh Company has modified this method somewhat, as will be apparent from an inspection of the diagram, Fig. 1, which represents the connections for the same-circuit method now employed. The working standard, WS, is a low-voltage lamp connected in series with two adjustable resistance, R2 and WSR. In parallel with this lamp and the resistances is placed the lamp, TL, to be tested, and two adjustable resistances, R1 and MR, are connected in series with both. The resistances MR and WSR are very finely graduated, for final adjustments to accurate values; the others are coarser in graduation, for approximating the proper adjustments.

If the rate of change of candles with a given percentage change of voltage were exactly the same for lamps of all types there would be no need for further explanation. As a matter of fact, however, incandescent lamps do not all change exactly alike in candles because of differing hot resistance and emissivity characteristics. It is due to this fact that there is a possibility for a small theoretical error in the same-circuit method. Practically, this error is so small that more accurate work can be done by ninety-nine out of every hundred users of the same-circuit plan than with any other. With the same care in voltage regulation, there is at all times less error with the same-circuit method, and where exact voltages are maintained there is absolutely no error. As no other method is operative without an exact maintenance of voltage it will be plain that the modified same-circuit method is preferable for ordinary photometric measurements in central stations.

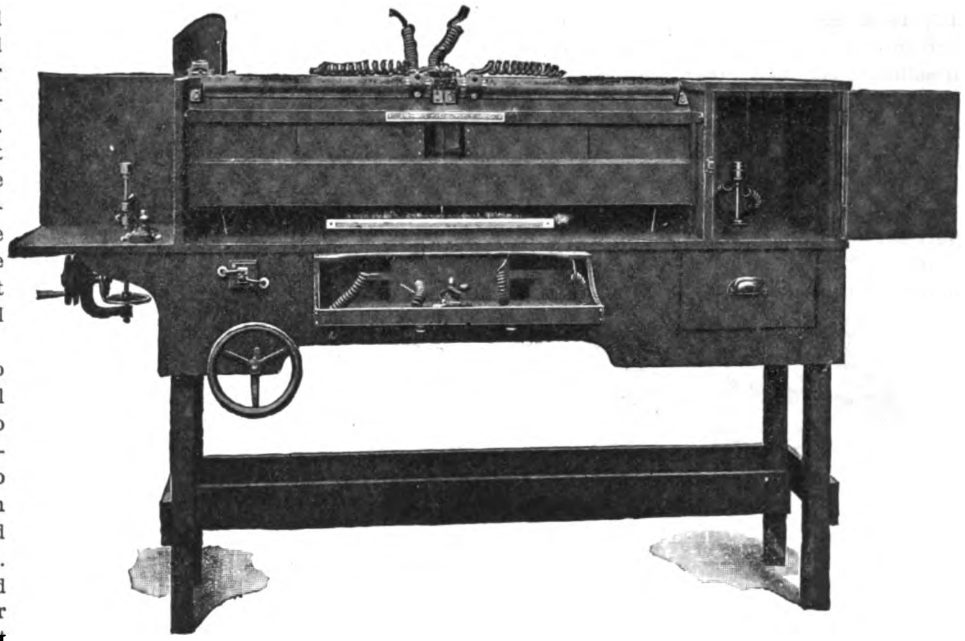


FIG. 2.—PHOTOMETER FOR EITHER SAME-CIRCUIT OR SEPARATE-CIRCUIT WORK.

When it is considered that 15 volts variation on a 110-volt 16-c.p. lamp can introduce an error of only about ¼ candle-power, maximum, and that an ordinary observer can notice no relative change in illumination on the usual commercial circuit, it will be evident that it is unnecessary to consider the error due to this cause.

The photometer illustrated by Fig. 2 is constructed on the familiar Bunsen principle. The exact shape and dimensions of the opening in the front of the car, the height of the car, and the size of the grease spot have all been made subjects of extremely careful consideration with a view to giving a minimum amount of fatigue to the eyes in testing a large number of lamps. The candle-power scale and current-indicating instruments are illuminated by lamps supplied from a separate circuit and shielded so that their rays cannot reach the observer's eyes or the photometer box. The front of the box is fitted with light screens which slide past each other as the car is moved back and forth, so that the box is at all times shielded from stray light except such as may pass in at the space through which the observer reads the mirrors.

The working-standard lamp is entirely shielded so that the only portion of the photometer which is ordinarily susceptible to the influence of outside light is that immediately around the lamp being tested. It is impossible to avoid this without sacrificing speed in measuring a large number of lamps, but for a limited number of measurements, where speed is not an object, curtains can be drawn about this end of the instrument so as to eliminate all possibility of interference.

The rotator is arranged in a novel manner so as to facilitate the insertion and withdrawal of test lamps. The rotator spindle carries below the table two friction discs and is movable up and down in its bearings so that either one of the friction discs can be put in contact with the driving disc located at right angles to them. Normally the weight of the spindle and discs keeps it down, with the upper of the two friction discs in contact with the rim of the driving disc. When in this position the rotator is driven counter-clockwise, so that simply holding a test lamp with its base in the mouth of the socket causes it to screw into place. When the lamp is to be removed the operator grasps the bulb and raises the spindle until the lower of the two friction discs comes into contact with the rim of the driving disc, reversing the direction of the rotator and unscrewing the lamp from the socket.

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*See American Electrician for October, 1899.

The tray in the front of the photometer table is wired ordinarily for a Weston voltmeter and ammeter, but when desired it is fitted for a wattmeter. The handwheel at the left operates the car along its track.

The operation of the photometer will not require any explanation to those accustomed to make photometric measurements, but it may be of benefit to others to outline the process. The working standard is screwed into the socket at the right-hand end of the instrument and the socket twisted around until there are no filament shadows on the screen; then a primary standard of known characteristics is inserted in the test socket. The arrow near the top is adjusted to point directly at the center of the screen; then the car is adjusted to bring the pointer opposite the figure on the scale corresponding with the candle-power of the primary standard. With the car in this position current is turned on and the coarse resistance, R1, Fig. 1, is adjusted until the e.m.f. at the terminals of the primary standard is approximately its rated voltage; then the finely-graduated resistance, MR, is manipulated until the precise e.m.f. is obtained. When this is done, the coarse resistance, R2, is adjusted until the spots on the screen come as near balancing as it is possible to get them; then the finely-graduated resistance, WSR, must be employed to make the spots balance precisely. It will be found that the manipulation of the resistances, R2 and WSR, have caused a change in the e.m.f. at the terminals of the primary standard so that MR will have to be adjusted until the e.m.f. comes back to the rated voltage of the primary standard; then the car is moved backward and forward and independent readings taken; the resistance, WSR, is further adjusted until the average of these readings is exactly that of the primary standard.

The status of the instrument is then checked by taking a careful voltmeter reading at the terminals of the primary standard in order to be positively certain that the spots balance with the car set at the candle-power of the primary standard while the e.m.f. at its terminals is the rated voltage; then the e.m.f. at the working standard is rated. Next, the primary standard is removed from the test socket and without any further adjustment of the resistances lamps rated at the same voltage as the primary standard may be tested without regard to the actual voltage at the terminals of the working standard and the test lamp at the same time of the readings. The readings will be in terms of candle-power delivered at the rated voltage of the primary standard and the lamps being tested, regardless of the actual voltage.

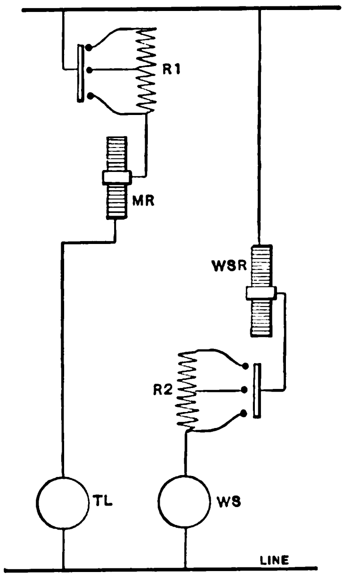

FIG. 3.—SEPARATE-CIRCUIT CONNECTIONS.

The object in noting the e.m.f. at the working standard when finally checking up the adjustment of the photometer is to enable the operator to test lamps of other voltages than that of the primary standard. In order to adjust the instrument for such a test one of the lamps to be tested is inserted in the test socket and the resistances adjusted until the e.m.f. at its terminals is its rated voltage and that at the terminals of the working standard is the voltage previously noted, regardless of the candle-power delivered by either of the lamps. The photometer is then in a condition for measuring the new lot of lamps.

The photometer connections are so arranged that simply changing the plug from one hole to another changes it from a same-circuit to a separate-circuit instrument, or the reverse. When arranged for separate-circuit work the connections are as shown in Fig. 3. The process of testing by this method is too well known to require any detailed description.

AUTOMOBILE MOTORS.

BY J. C. LINCOLN.

The requirements of an electric horseless carriage have created a demand for a type of motor not previously produced. The service demands a motor which shall be light, which shall be capable of operating at an overload of several hundred per cent, and which shall at the same time be highly efficient at an ordinary running load. There is no doubt in the minds of automobilists that the variation in power required from an automobile motor is greater than that required from any other type. The street car motor most closely approaches it in function and conditions.

It is very difficult to obtain in a series motor for automobiles a fair efficiency when overloaded, and a high efficiency with regular running loads, on account of the extraordinary variations of load. For instance, in one carriage weighing 1600

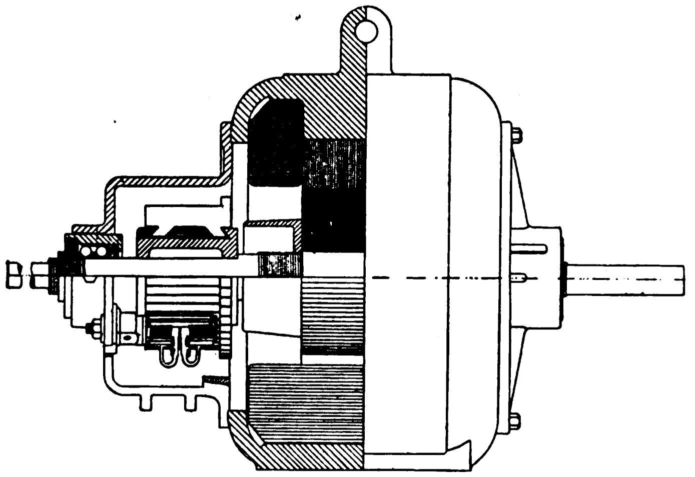

FIG. 1.—AXIAL SECTION OF LINCOLN AUTOMOBILE MOTOR.

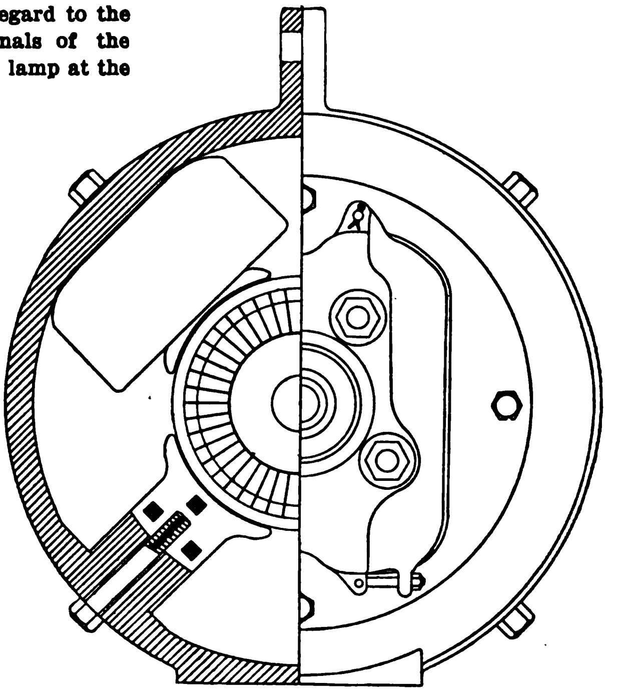

FIG. 2.—CROSS SECTION OF LINCOLN AUTOMOBILE MOTOR.

lbs. without passengers and 2000 lbs. with passengers, 6800 watts were required to drive it up an 11 per cent grade at a speed of about seven miles per hour. The same carriage with the same load requires 360 watts to drive it on a brick pavement at a rate of eight and a half miles per hour.

It is a well-known fact that the efficiency of a series motor is very low until enough current flows through the field coils of the motor to produce considerable magnetic flux, and while a series machine can take extreme overloads with fair efficiency it is apt to have a low efficiency on good smooth ground, because the work required of the motor is so small under the latter condition.

The motor illustrated herewith, as well as its controller, is designed to overcome in a considerable degree the objections noted. This machine, which is built by the Lincoln Electric Company, Cleveland, Ohio, is compound wound, and the controller is arranged so that the shunt field is constant whatever the voltage on the armature may be. The strength of the shunt field is the same whether the motor is running with 20, 40, or 80 volts. This arrangement makes it possible to obtain a very high efficiency at low loads which is not possible with a series motor. Another very important advantage is the saving of most of the power which is usually wasted as friction in mechanical brakes.

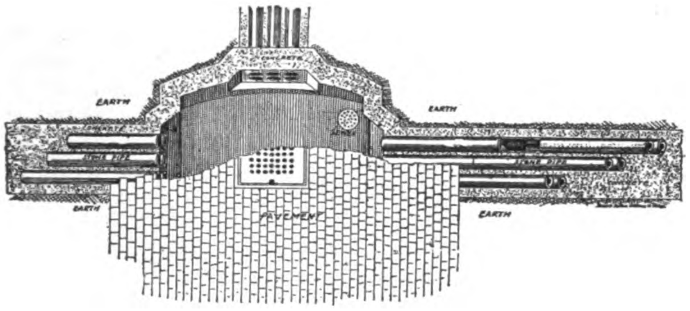

FIG. 1.—PLAN VIEW OF MANHOLE AND CONDUIT.

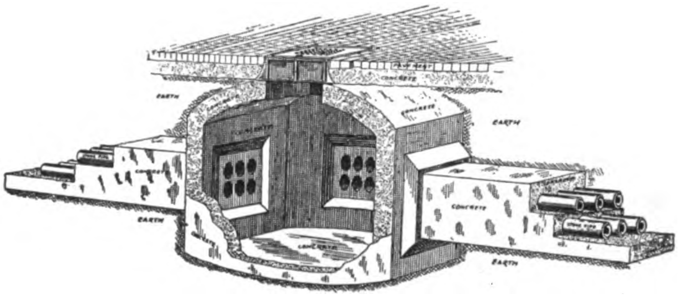

FIG. 2.—A SECTIONAL VIEW OF MANHOLE AND CONDUIT.

This motor drives a carriage carrying 40 cells of battery at about 4 miles an hour on the first speed, or with 20 volts at the brushes; the rate is 8 miles an hour on the second speed, with 40 volts at the brushes, and 16 miles an hour on the third speed, with 80 volts (the battery all in series) at the brushes. The advantage of the shunt winding may be best shown by taking a concrete example. For instance, suppose this carriage is traveling at a rate of about 8 miles an hour and begins to descend a grade; the speed will be increased and the counter e.m.f. of the armature will increase at a rate of about 9 miles an hour, no current will pass through the armature, and when the speed rises to about 9½ miles, the counter e.m.f. will have still further increased, so that the motor becomes a generator and charges the batteries. Any greater increase in the speed of the carriage is impossible because a slight increase will very greatly increase the load on the motor by increasing the charging current.

If it is desired to descend a hill at a lower rate of speed than between 9 and 10 miles an hour, the controller can be moved to the first speed, and it will be impossible for the carriage to descend at a higher rate of speed than 5 miles an hour; and the power which would have been wasted in the friction of the mechanical brakes in descending the hill will be used in driving the motor acting as a dynamo and charging the storage batteries. This is also valuable in bringing the carriage to a lower speed on level roads. If the carriage is traveling at the highest speed and the controller is moved to the second speed the momentum of the carriage drives the motor as a dynamo and rapidly charges the battery until the speed drops to 8 or 9 miles an hour. When the speed decreases so that the batteries are no longer being charged, the controller can be placed at the first speed and a still further charge of the batteries effected. This brings the speed to about 4½ miles an hour.

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AMERICAN ELECTRICAL WORKS' ANNUAL CLAM BAKE.

The twenty-second annual clam bake of the American Electrical Works, Providence, R. I., was given at the Pomham Club, Pomham, on Narragansett Bay, September 13th. About 400 guests were present and every one of them voted the dinner a huge success. The American Electrical Works is one of the oldest wire manufacturers in the elctrical field, and its custom of giving a clam bake once a year was inaugurated in 1878. On this occasion only 18 guests were present, of whom three are still living, notwithstanding their successive visits to the annual feast. A light luncheon was served upon the arrival of the guests at the club house, after which those present engaged in various forms of amusement, such as target-shooting, bowling, billiards, etc. At 2 o'clock in the afternoon the clam bake was served. The dinner closed with a series of toasts, Thos. D. Lockwood acting as toastmaster. Mr. Phillips made a short address expressing his pleasure at greeting his guests, and the following toasts were offered and responded to by the gentlemen whose names follow respectively the toasts: "The City of Providence and State of Rhode Island," D. J. Hayden; "The Telegraph," Prof. Elisha Gray; "The Electrical Fraternity," Col. Van Slyck; "Power Transmission," Major R. S. Brown, of the Westinghouse Company; "The Technical Press," J. M. Wakeman, president of the "Electrical World and Engineer." The speeches closed with an address by Mr. Lockwood expressing the thanks of the assembly to Mr. Phillips for his unfailing hospitality, which was seconded by everybody present with three cheers. Each of the guests received a handsome and useful souvenir in the shape of a highly-burnished match safe embossed with the trade-mark of the American Electrical Works.

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AMERICAN STONE CONDUIT.

The electrical conduit problem has received much attention in the past decade from inventors, electrical companies and public authorities, and many meritorious systems have been developed as a result. One of the latest of these to bid for favor is that of the American Stone Conduit Company, Chicago, Ill., of whose material and method two illustrations are furnished by Figs. 1 and 2 herewith. The ducts are made of a mixture of crushed stone and Portland cement, which makes a structure that is claimed to be proof against electrolysis, acid, water and gas, and practically indestructible. In the course of manufacture the pipes are subjected to an internal pressure of 2500 lbs. per square inch, which gives the interior of the pipe a smooth finish, with a uniform diameter, and a consequently uniform strength and density. The ducts are cured by water, no kiln-drying or burning being employed to attain this result; and the older the pipe and the longer its exposure, the harder and stronger it becomes. These pipes are made in lengths of 6 ft., and they can be easily sawed to shorter lengths and to any angle. When they are laid in place the cement unites with the exterior of the ducts so tenaciously as to form a solid structure of stone of great resistance to mechanical strains from without. Perfect alignment of adjoining pipes is secured by using a rubber mandrel in laying the ducts in concrete. The machines used in the manufacture of these ducts turn out one pipe each every 40 seconds. An important advantage offered by this system is that the construction of a subway may be accomplished very rapidly, using only ordinary labor throughout the entire work.

New Apparatus and Appliances

WARD LEONARD CONTROLLER FOR PRINTING PRESS MOTORS.

Fig. 1 illustrates a recent type of rheostat controller built by the Ward Leonard Electric Company, Bronxville, N. Y., for controlling motors driving large printing presses or performing other work of a generally similar character. The speed-regulating part of the instrument is an ordinary Carpenter rheostat with liberal contact and radiating surfaces, designed for continuous service. The special feature of the instrument is the "fool-proof" arrangement for opening and closing the circuit. This consists of a knife-blade switch located to the right of the rheostat lever, and adapted to be thrown by the end of the lever which projects below the pivot. This end engages with one of the two lugs of the Y-shaped cam, which is adapted to throw the switch; the movement of the switch lever is entirely independent of the movement of the rheostat arm, after the cam has once been started. This makes it impossible for a careless attendant to burn the contacts of the rheostat by drawing an arc when shutting off the motor or by making insufficient contact in starting, as the knife-blade switch opens and closes the circuit before the rheostat brush leaves or touches the first contact block. The apparatus also includes the well-known combined overload and underload Ward Leonard circuit-breaker known as the "DK" type, which is used on most of the automatic motor starters made by this company. The right-hand magnet of the two, which sets obliquely on the slab, is the no-voltage release, and the vertical magnet actuates the overload circuit-breaker. The engraving shows the circuit-breaker thrown.

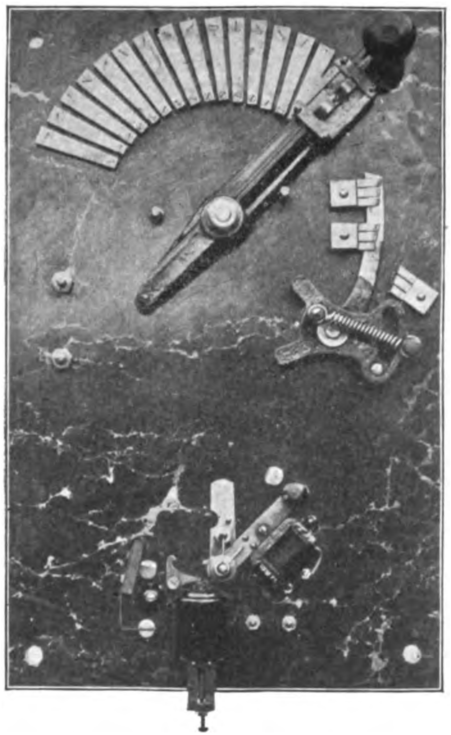


FIG. 1.—PRINTING PRESS CONTROLLER.

"NEW YORK" TRAP.

The National Automobile & Electric Company, of Indianapolis, a newcomer in the "horseless" field, has made its debut with a wagon called the "New York" trap, which is illustrated by Fig. 2. The machine is intended for park and boulevard use in large cities, and, as will be seen from the engraving, has rather fine lines with a suggestion of power about it. It has a radius of about 50 miles on one charge of the battery. The motor equipment is a 2½-h.p. machine geared directly to the rear hubs, and has a compensating gear in the motor shaft. The running gear frame is tubular, the wheels are wood with solid rubber tires, and the vehicle is fitted with ball bearings throughout. It has five speeds forward and three backward; the maximum forward speed is 15 miles an hour. It is substantially built, elegantly finished, and has been described by those who have witnessed its performance as moving with the quiet smoothness of a gondola.

The National Company will put out a line of electrics in some seven or eight styles, including road wagons with or without tops, Stanhopes, four-passenger brakes, small dos-a-dos park traps and combination delivery and pleasure wagons. The appearance of these at the Madison Square Garden next November will be noted with considerable interest.

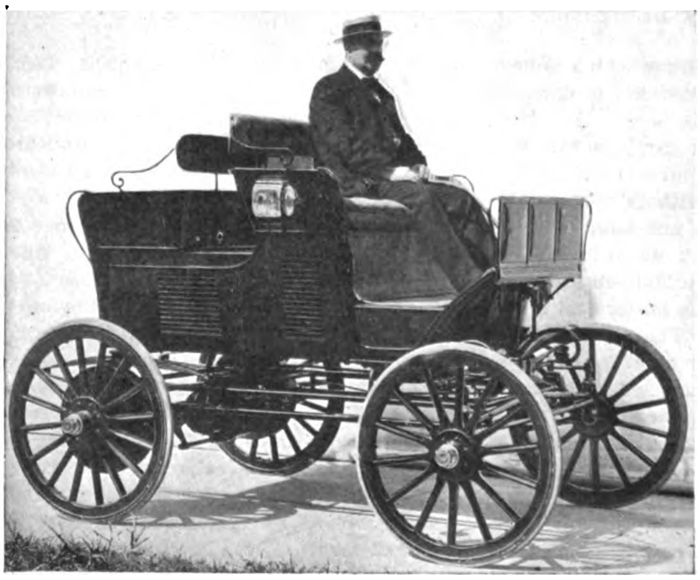


FIG. 2.—THE "NEW YORK" TRAP.

A NEW AMMETER.

Fig. 3 represents a new ammeter manufactured by Kendrick & Davis, Lebanon, N. H. The instrument is of the ordinary galvanometer type, the magnetic field being supplied by a permanent magnet made of a special grade of steel. The needle is made of aluminum and the pivots are of hardened steel set in brass bearings. The scale is inked in by hand, each instrument being individually calibrated, and a leveling screw is provided at one end of the base so that the indicator needle may be brought to zero when the instrument is resting on a surface which is not accurately level. The case is of hard wood, finely polished; the binding posts are of an improved type specially designed to prevent the contacts between them and the winding from coming loose. The instruments are calibrated from 0 to 14, and are furnished calibrated and wound for measuring e.m.f. as well as current.

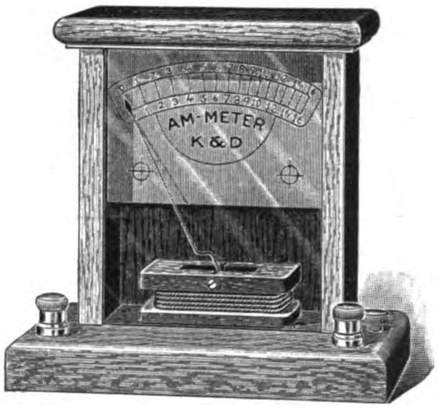
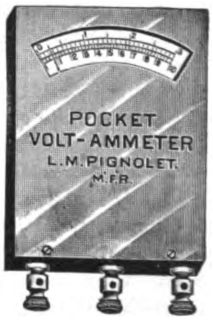


FIG. 3.—K. & D. AMMETER.

COMBINED VOLTMETER AND AMMETER.

Louis M. Pignolet, New York, manufacturer of electrical instruments, is putting out an attractive little volt-ammeter in pocket size which is illustrated by Fig. 4. These instruments are of the permanent-magnet type and the indications are very nearly dead-beat. Each scale is calibrated individually by hand and the bottom of the scale is provided with a mirror for accuracy in making readings, as is the case in all standard instruments. The magnets are of special steel and carefully treated to prevent any aging effect. The instrument has jewel bearings and steel pivots, the latter being carefully ground and hardened. The case is handsomely polished and nickeled, and measures only 3x4 ins., so that it can be readily carried in the pocket. As the name indicates, the instrument can be used for measuring either current or e.m.f. The range of the instrument normally is 4 volts, and it can be furnished with a range of 0 to 1 ampere, 0 to 4, 0 to 10, or 0 to 15 amperes


POCKET
VOLT-AMMETER
L. M. PIGNOLET.
M.F.R.
FIG. 4.

as may be desired. Special instruments are also made with voltage ranges of 10 20 and 50 volts instead of 4 volts.

A NEW DESK TELEPHONE OUTFIT.

Thomas, Wilcox & Dietz, Cleveland, O., are offering the telephone desk set illustrated by Fig. 6, which embodies all the advantages usually found in modern high-grade telephone instruments. The set has a granular carbon transmitter, a powerful double-pole receiver, and a new form of receiver hook. The induction coil is mounted in the base of the transmitter standard and the whole standard is heavily nickel-plated and highly polished. With the addition of a selective switch this outfit can be used as a station of an intercommunicating system. It is furnished with either magneto or battery call.

STEWART PATENT CORD ADJUSTER.

Frank H. Stewart & Co., Philadelphia, have recently been granted a patent for the simple cord adjuster illustrated by Figs. 5 and 8. The manufacturers explain that they have had considerable trouble with various kinds of cord adjusters, the chief difficulty being that they would take only one size of cord. The result of these annoyances has been the design of the cord adjuster illustrated here. As plainly shown in the illustrations, the transverse slots nearest the ends of the adjuster have each a constricted opening which obviates any liability to the cord slipping out of the slot sidewise. The crescent-shaped slot in the center of the adjuster forms an effective means for jamming the cord at each end. One of the most convenient features of this little device is that it can be readily attached to and detached from pendant lamp cords which are already in position. Fig. 5 shows a method of disposing of the surplus cord which is considerably neater than the usual method, illustrated by Fig. 8, although a trifle more troublesome to arrange. The adjuster is made of hard fiber.

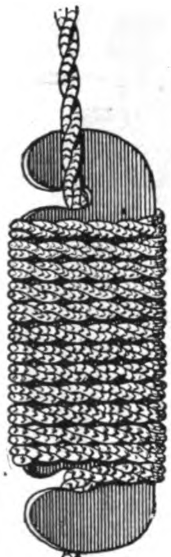


FIG. 5.

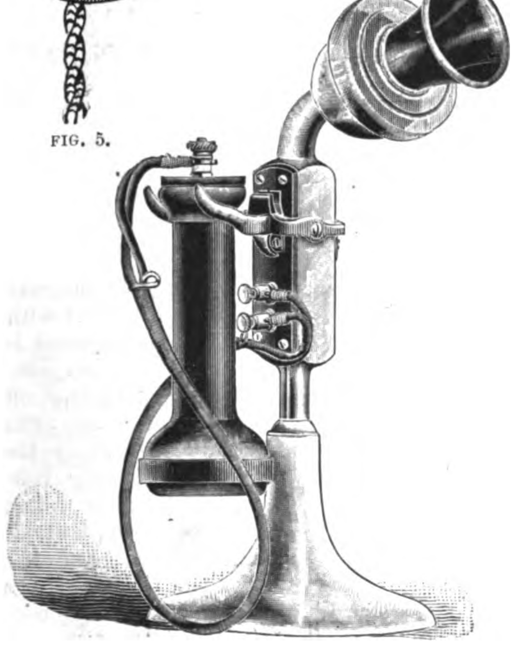


FIG 6.- NEW DESK TELEPHONE.

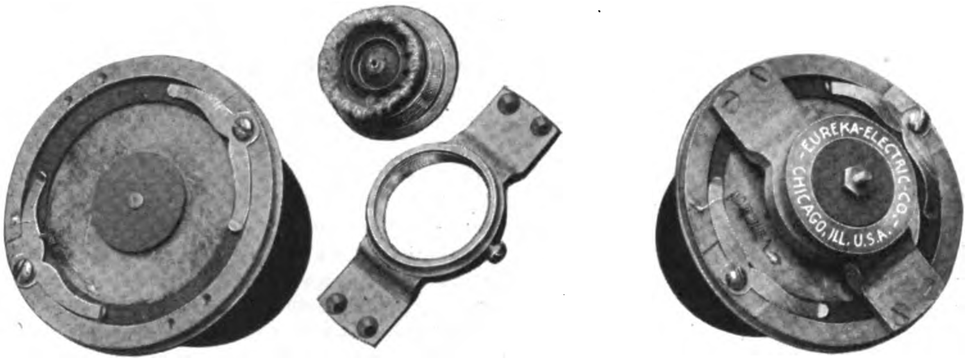


FIG. 7.—EUREKA ADJUSTABLE SOLID BACK TRANSMITTER.

EUREKA TELEPHONE TRANSMITTER

The new "Eureka" special transmitter, illustrated by Fig. 7 and manufactured by the Eureka Electric Company, of Chicago, is one of the few adjustable transmitters offered by independent makers, and is said to possess superior and special points of merit. It is a solid front as well as a solid back transmitter, as heavy lathe-turned castings are used in its construction. The back is a heavy stamping of No. 12 gauge brass. The transmitter is beautifully nickeled and very finely finished. It is a special high resistance instrument measuring 750 ohms in resistance—a special advantage claimed by the makers on the ground that high-resistance transmitters are very economical in the consumption of battery power. Auxiliary springs are employed, and the damper is pressed firmly against the diaphragm. Special carbon is used, of the company's own manufacture. This transmitter is guaranteed absolutely against any possibility of packing, and is said to be capable of standing very heavy battery current without heating or arcing, thereby obviating any rasping or harsh tones and sounds. Out of the several thousand placed upon the market already, the company states that not a single one has been returned or had a complaint entered against it for any cause whatsoever.

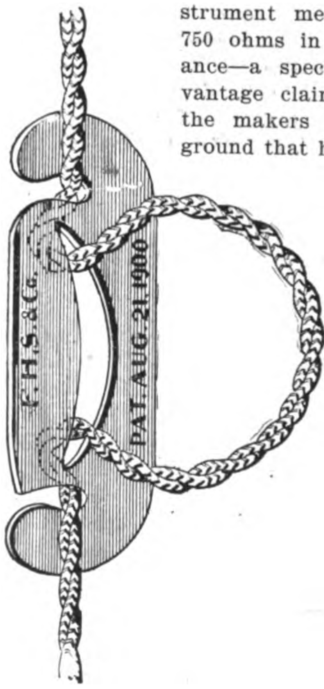


FIG. 8.- STEWART ADJUSTER.

DENTAL AND SURGICAL AIR PUMP

A very compact motor-driven air pump and reservoir tank for dental and surgical purposes is being put out by the Emerson Electric Manufacturing Company, St. Louis, Mo. This outfit is illustrated by Fig. 9 and consists of a single-acting air pump with metallic ball valves, driven by an Emerson alternating-current motor and connected by 2 ft. of pressure hose to a 6-gal. nickel-plated tank. The tank is provided, as shown in the illustration, with a pressure gauge and two stop-cocks and hose connections for leading off to delivery tubes. The outfit is designed to maintain a pressure of 20 lbs. in the tank, but the pump will compress up to 30 lbs. pressure if necessary. It has a capacity of about 1½ gals. of free air a minute and will bring the pressure in the tank up to 20 lbs. in 6½ minutes. The uses of this outfit are too numerous for detailed mention. The advantages of it are obvious. Among the better-known purposes for which it is adapted are supplying atomizers in treating nose, mouth and throat troubles, and for dental use,

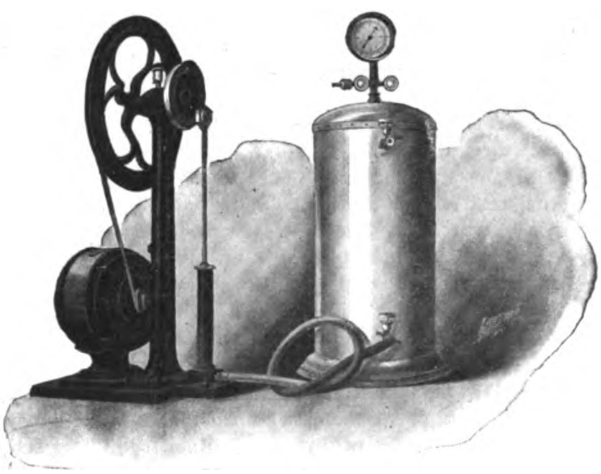


FIG. 9.- DENTAL AND SURGICAL AIR PUMP AND TANK.

such as clearing out cavities in the teeth. The portability of the outfit is one of its greatest recommendations, of course, and the cost of operation is practically insignificant. The only part of the pump which may require renewal is the leather packing of the piston, which can be replaced in a few minutes at a nominal expense. The outfit is supplied for operation from either 60-cycle or 133-cycle circuits of 52 or 104 volts.

CLARKE AUTOMATIC COAL SCALES.

Two forms of a new automatic scale for measuring the coal consumption of central stations or other power plants are illustrated by the accompanying engravings. The vertical scale, Figs. 10 and 11, is intended for use between the bunker and the stoker, and the rotary form, Fig. 12, is for service where continuous weighing is required.

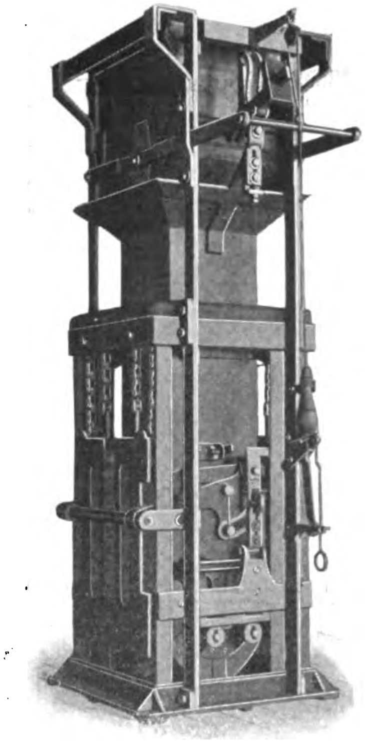


FIG. 10.—VERTICAL SCALE IN RECEIVING POSITION.

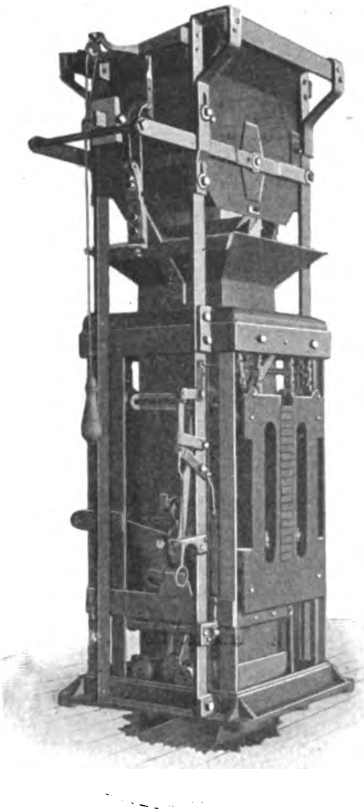


FIG. 11.—VERTICAL SCALE DELIVERING ITS CHARGE.

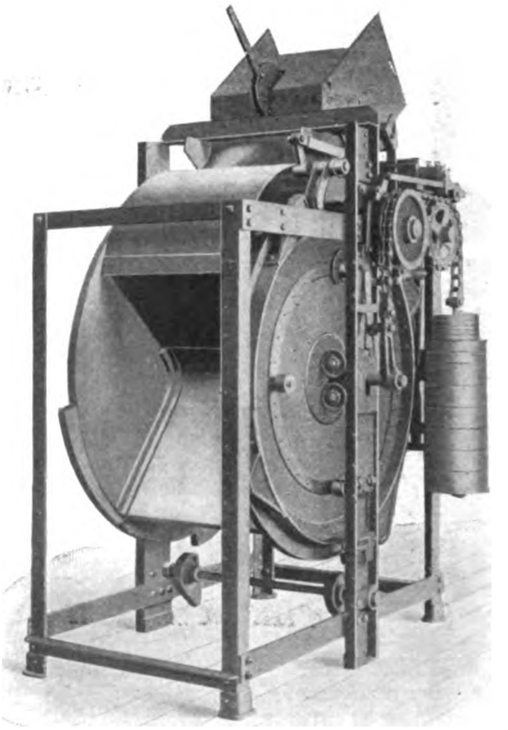


FIG. 12.—ROTARY WEIGHING MACHINE IN POSITION OF DELIVERY.

In the vertical type the coal which flows into the upper hopper passes down between two open gates into the weighing hopper. These gates are of a peculiar design, somewhat resembling in section an upwardly pointed hook, and close the outlet of the first hopper by cutting directly across the outgoing stream. The two streams of coal impinge on a narrow saddle back, or spreader, which materially lessens the force of impact against the bottom of the weighing hopper. When the latter is nearly full—i.e., when the required weight of coal has almost passed through—the larger weights are slightly lifted and the whole system is held in a state of partial equilibrium. In this position two auxiliary weights on the sides of the hopper are held by the clip and cam roller device shown in Fig. 10. When sufficient coal has run in to lower the hopper to the point where the cam pushes out the clip, these two auxiliary weights are released and are added to the weight of the coal in the hopper. This addition causes the latter to drop immediately to the position shown in Fig. 11, suitable simple appliances being used to open the lower jaws of the weighing hopper and allow the escape of the coal and to close the gates of the upper or supply hopper. A pull on the wire loop at the corner of the machine releases a catch and allows the main weights to pull the empty hopper and auxiliary weights back to the original position at the same time, again opening the gates of the supply hopper. An ingenious double-tripping device prevents the possibility of holding the catch back and allowing a continuous stream of unweighed coal to pass. The action of the catch can be made automatic by the use of a secondary hopper having a tilting bottom which pulls a connecting chain. The other handle operates an agitator in the upper hopper to relieve any congestion which may occur in the supply. Guiding rollers are provided to keep the heavy moving parts in place, but at the moment of equilibrium they swing practically free, while the chains connecting the hopper with the weights pass over ball-bearing sprocket wheels. In order that the different sizes of coal will each of them just fill the hopper for the given weight, internal vanes are provided which change the bulk of the charge. The last coal which enters before the clip is released, therefore, is laid gently on the top and there can be no error due to the impact increasing the downward force.

The same general features are incorporated in the rotary scale, Fig. 12, with a few necessary adaptations. In this case the auxiliary weights slide in the channel bar which forms the central support. The axle has a slight vertical motion, so that when one of the segmental hoppers into which the drum is divided has received its allotted charge, it drops down and releases the mechanism which keeps the drum from revolving. Before the catches are released, however, the same state of partial equilibrium takes place while the auxiliary weights are automatically suspended, as in the vertical scale. The center of gravity of the coal in the weighing hopper is 10° ahead of the vertical line through the axle, and the ratchet-like teeth on the edge of the drum coming in contact with stops at the rear as the drum drops throws it around with great rapidity. This weighing process is entirely completed before the drum commences to revolve, the coal being shut off before any movement takes place. The drum is raised again to position by the eccentric periphery acting on the rollers at the bottom, the velocity being at the same time arrested by the braking action of springs at the back and the cams on the rollers. The rate of supply is regulated by an adjustable vane operated by the handle protruding from the supply hopper.

These weighing machines are two of the latest designs made by P. B. Clarke, and are being manufactured and put on the market by the Clarke Automatic Scale Company, New York.

TWEEDDALE WATER PURIFYING AND SOFTENING SYSTEM.

The accompanying illustration, Fig. 13, represents somewhat roughly the Tweeddale water-purifying and softening apparatus manufactured by the Chicago Boiler Cleaner Company, Chicago, Ill. The apparatus consists of a pair of tanks which hold each a supply of water sufficient for about 6 hours' run. In the bottom of each tank is located a device which is called an "aerator and oxidizer," and consists of a system of metallic plates with layers of coke in between them. A strong jet of air is passed through the oxidizer pipes, producing an agitation and aeration of the water, with which is mixed a small quantity of chemical reagent injected at the proper moment. The theory is that when this agitation ceases the base of the reagent forms a coagulated mixture which seizes the impurities in the water and carries them down to the bottom of the tank by precipitation.

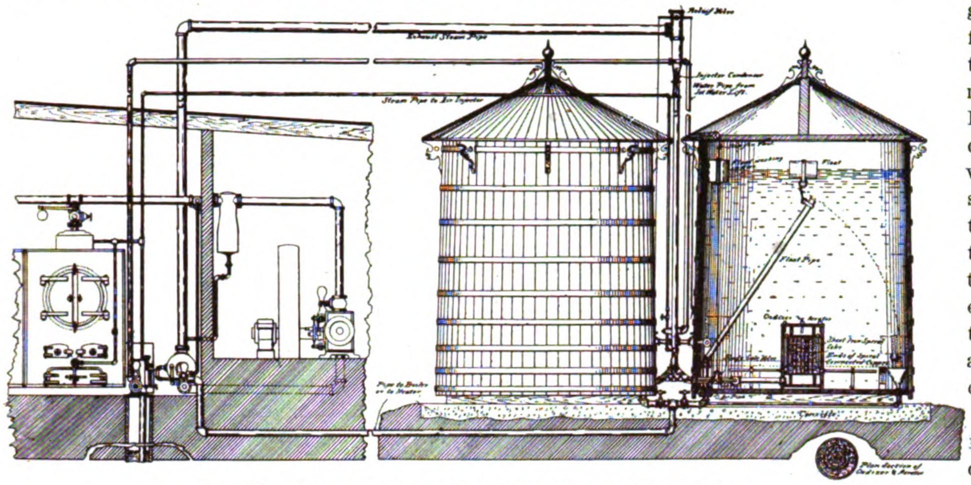

Relief Valve
Exhaust Steam Pipe
Steam Pipe to Air Injector
Injector Condenser
Water Pipe from Jet Water Lift
Float
Float Pipe
Oxidizer & Aerator
Pipe to Boiler or to Heater
Concrete
Plan Section of Oxidizer & Aerator

FIG. 13.—TWEEDDALE WATER-PURIFYING APPARATUS.

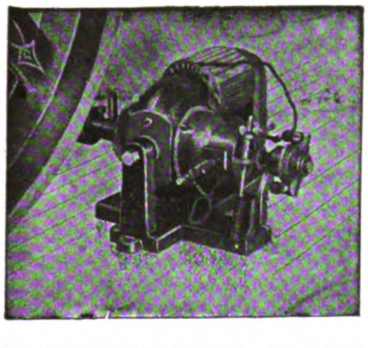


FIG. 14.—AUTOSPARKER GAS ENGINE IGNITER.

It is claimed that water which was cloudy and muddy before being passed through the tank becomes perfectly clear and softened. The purified water is drawn from the surface by floating-pipe connections, and the precipitated impurities are carried away by waste pipes from the bottom of the tanks. The two tanks are exactly alike, the purifying process being carried on in one tank while water is being taken from the other one. No mechanical filter is used.

The manufacturers state that the Edison Electric Illuminating Company, of Topeka, Kan., after having so much trouble with scale as to almost cause them to abandon the use of water-tube boilers, put in a Tweeddale purifier with a capacity of 100,000 gals. a day, with the result that after a year's service the boilers show no scale formation whatever.

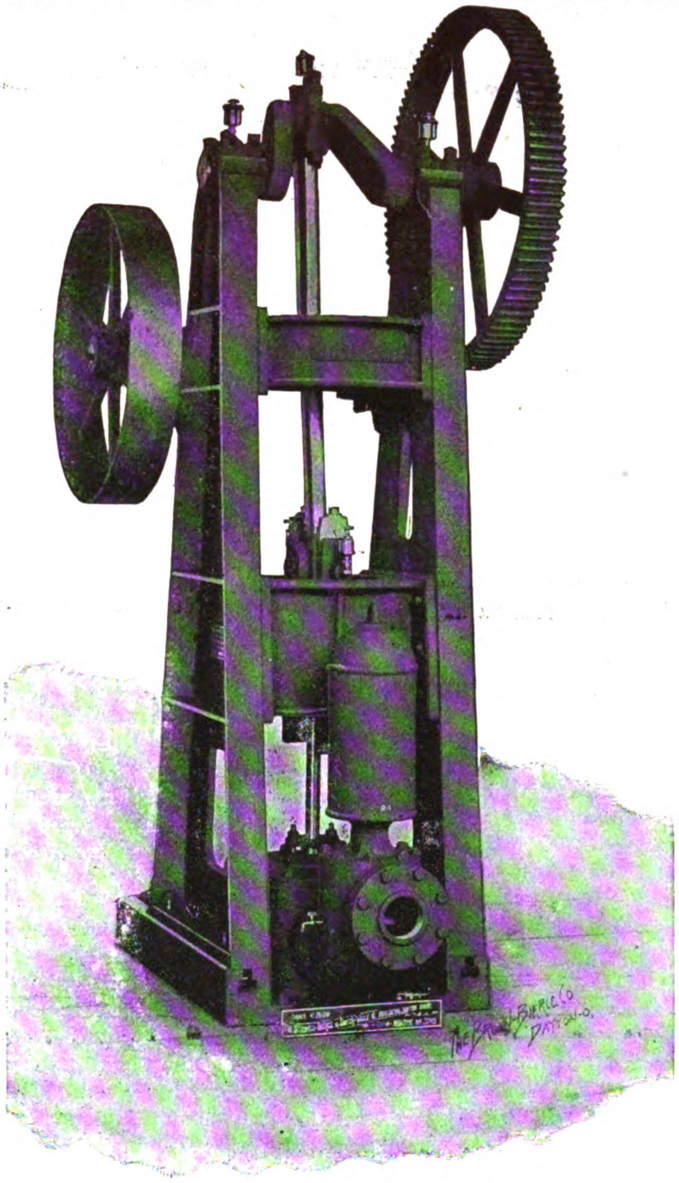


FIG. 15.—SMITH-VAILE DEEP WELL PUMP HEAD.

THE AUTOSPARKER GAS IGNITER.

One of the chief objections to the use of small generators for igniting gas engines is the fact that if they give the proper e.m.f. when the engine is running at its normal speed, the e.m.f. is not sufficient for ignition when the engine is just starting up, and a battery must be used for this purpose until the engine attains a speed somewhere near its normal rate. If, in order to obviate the use of a battery, the generator is built to give sufficient e.m.f. for ignition at the very low speed then the e.m.f. is too high when the engine is running at normal speed. The Motsinger Device Manufacturing Company, of Pendleton, Ind., solves this problem by providing a small centrifugal governor on the shaft of the igniting generator, the function of which is to vary the relation between the generator friction wheel and the fly-wheel of the gas engine. The generator is driven by friction, as shown in the engraving, and it is pivoted at right angles to the shaft. The governor on the commutator end of the shaft acts to tilt the dynamo between its pivots; when the speed exceeds the proper limit the governor tilts the dynamo so that its friction wheel loses contact with the rim of the engine fly wheel.

SMITH-VAILE DEEP-WELL POWER PUMP.

Fig. 15 illustrates a Smith-Vaile deep-well power pump head of the differential type, manufactured by the Stilwell-Bierce & Smith-Vaile Company, Dayton, Ohio. The pump head is suitable for both open and drilled wells. The stroke is 24 ins., and the machine is adapted to almost any size of working barrel, within the limit of course imposed by the maximum lift. The crank is of steel; the gears are of charcoal iron, machine cut. The secondary shaft carrying the belt pulley runs in self-oiling bearings of the ring type; the connecting rod is of steel with a bronze box at the crank end, and an adjustable box at the cross-head end; the cross-head works in an adjustable shoe. A combination water-box base is provided in which are located the check valves. This apparatus has been installed in several large office buildings, notably the Montgomery-Ward Building in Chicago, where it raises water 375 ft. The pump may be driven, of course, by any suitable source of power, being designed for belt driving.

Among the Exhibitors at the Paris Exposition.

A perusal of the report of awards made by the Paris Exposition authorities to exhibitors in the machinery and electricity classes shows that the American manufacturers, as usual, have come off with triumphantly flying colors. The itemized list of awards as made out by Director F. E. Drake is as follows:

GROUP IV.—MACHINERY.

CLASS 19.

Gold Medal—Ball Engine Co.; Geo. F. Blake Mfg. Co.; William Sellers Co. *Silver Medal*—Ashton Valve Co.; Clonbrock Steam Boiler Co.; Crane Co.; Lee Injector Co.; Lunkenheimer Co.; Schaffer & Budenberg; Walworth Mfg. Co.; Wheeler Condenser & Engineering Co. *Bronze Medal*—Ambler Asbestos Air Cell Covering Co.; American Steam Gauge Co.; W. D. Forbes & Co.; Keystone Engineering & Mfg. Co.; Charles D. Mosher; Taunton Locomotive Mfg. Co. *Honorable Mention*—Joseph De Rycke; Direct Separator Co.; Fiske Bros. Refining Co.; H. W. Johns Mfg. Co.; G. T. McDondland; Sherwood Mfg. Co.; United States Metallic Packing Co.

CLASS 20.

Silver Medal—Mietz & Weiss; Rider-Ericsson Engine Co.; S. Morgan Smith Co. *Bronze Medal*—Pelton Water Wheel Co. *Honorable Mention*—Ingersoll-Sergeant Drill Co.

CLASS 21.

Grand Prix—Batcheller Pneumatic Tube Co.; Otis Elevator Co.; Worthington Pumping Engine Co. *Gold Medal*—Crane Co.; Ingersoll-Sergeant Drill Co.; Tinius Olsen & Co.; Rand Drill Co.; Charles A. Schieren & Co.; Shaw Electric Crane Co. *Silver Medal*—American Steel Pulley Co.; Chapman Valve Mfg. Co.; Lunkenheimer Co.; Monarch Governor & Machine Co.; Rice Gear Co.; Robins Conveying Belt Co.; Thomson Meter Co.; W. S. Tyler & Co.; Walworth Mfg. Co. *Bronze Medal*—Ashton Valve Co.; Hugo Bilgram; Detroit Lubricator Co.; Fisher Governor Co.; Jeffrey Mfg. Co.; Ludlow Valve Mfg. Co.; Neptune Meter Co.; Stilwell-Bierce & Smith-Vaile Co. *Honorable Mention*—Bristol Co.; Christensen Engineering Co.; S. R. Dresser; A. H. Henderer's Sons; Locke Regulator Co.; F. D. Winkley.

CLASS 22.

Hors Concours — Kearney & Foot; Standard Tool Co. *Grand Prix*—E. W. Bliss Co.; Brown & Sharpe Mfg. Co.; J. A. Fay & Egan Co.; Niles Tool Works Co.; The Pratt & Whitney Co. *Gold Medal*—E. C. Atkins & Co.; Bement-Miles Co.; Bullard Machine Tool Co.; Chicago Pneumatic Tool Co.; Cincinnati Milling Machine Co.; Deering Harvester Co.; Gisholt Machine Co.; Hendey Machine Co.; Jones & Lamson Machine Co.; Morse Twist Drill & Machine Co.; Norton Emery Wheel Co.; Pond Machine Tool Co.; Simonds Mfg. Co.; Warner & Swazey. *Silver Medal*—Acme Machinery Co.; Baker Bros.; Becker-Brainerd Milling Machine Co.; John Becker; Cleveland Twist Drill Co.; Rockwell Clough Co.; Custis & Curtis; W. S. Doig; Fellows Gear Shaper Co.; Ferracute Machine Co.; Flather & Co.; Flather Planer Co.; Gleason Tool Co.; Gould & Eberhardt; William P. Healy; E. Horton & Son Co.; Ingersoll Milling Machine Co.; Landis Tool Co.; Morgan Machine Co.; Prentice Bros. Co.; Q & C Co.; Rice Gear Co.; H. B. Smith Machine Co.; Springfield Machine Tool Co.; L. S. Starrett Co.; Walworth Mfg. Co. *Bronze Medal*—American Machinery Co.; American Tool & Machinery Co.; American Turret Lathe Works; Armstrong Bros. Tool Co.; W. F. & John Barnes Co.; Bickford Drill & Tool Co.; Bradford Mill Co.; Builders' Iron Foundry; Cincinnati Planer Co.; Crane Co.; Herman Dock; Fosdick & Holloway Machine Tool Co.; Geometric Drill Co.; Goodall, Pratt Co.; George Gorton Machine Co.; Grant Machine Tool Works; Hart Mfg. Co.; Hoggson Pettis Mfg. Co.; R. K. LeBlond Machine Tool Co.; Morton Mfg. Co.; Oneida National Chuck Co.; Oster Mfg. Co.; Pearson Machine Co.; Potter & Johnson Co.; Pratt Chuck Co.; Prentiss Vise Co.; A. D. Quint; Safety Emery Wheel Co.; Springfield Mfg. Co.; Standard Pneumatic Tool Co.; Tremont Co.; Vitrified Wheel Co.; Waterbury Tool Co.; Westcott Chuck Co.; Whitman & Barnes. *Honorable Mention*—T. R. Almond; American Tool & Machinery Co.; —— Baldwin; James Clarke; D'Amour & Littledale; G. T. Eames & Co.; F. A. Errington; Leland-Faulconer Mfg. Co.; W. H. Nicholson & Co.; Oesterlein Machine Co.; Perkins Machine Co.; Perry Ransom; J. T. Slocomb & Co.; Universal Machine Co.; O. S. Walker & Co.

GROUP V.—ELECTRICITY

CLASS 23.

Hors Concours — Adams-Bagnall Co.; General Electric Co.; Hecla Iron Works; Charles T. Malcolmson. *Grand Prix*—American Steel & Wire Co.; Westinghouse Electric & Mfg. Co. Gold Medal—Bullock Electric Mfg. Co.; Lorain Steel Co.; Western Electric Co. *Silver Medal*—Crocker-Wheeler Electric Co.; Eureka Tempered Copper Co.; Jeffrey Mfg. Co.; Shaw Electric Crane Co. *Bronze Medal*—Albert & J. M. Anderson; Belknap Motor Co.; C & C Electric Co.; Jenney Electric Mfg. Co.; Lakon Transformer Co.; Milwaukee Electric Co.; New York & Ohio Co.; Pittsburg Transformer Co.; Standard Paint Co.; Stow Mfg. Co.; R. Thomas & Sons Co.; Thresher Electric Co.; Triumph Electric Co. *Honorable Mention*—Chase-Shawmut Co.; Circular Loom Co.; Crouse-Hinds Electric Co.; Crown Woven Wire Brush Co.; Garton-Daniels Co.; General Equipment Co.; Holmes Fibre-Graphite Co.; Wagner Electric Mfg. Co.

CLASS 24.

Grand Prix—E. C. Acheson.

CLASS 25.

Gold Medal—Alvin Mfg. Co.; Hart & Hegeman Mfg. Co.; Helios-Upton Co.; Holophane Glass Co.; Ward Leonard Electric Co.; Mica Insulator Co.; National Carbon Co.; Tiffany Glass & Decorating Co.; C. J. Toerring Co. *Silver Medal*—Bristol Co.; Dale Co.; Iron Clad Resistance Co.; New York & Ohio Co.; Oxley & Enos; Pass & Seymour; Phelps Mfg. Co.; United States Carbon Co. *Bronze Medal*—T. R. Almond; American Electrical Novelty Co.; Chase-Shawmut Co.; Chicago Fuse & Wire Co.; I. P. Frink; Incandescent Electric Light Manipulator Co.; William Inglis Wire & Iron Works; McLeod, Ward & Co.; E. B. Meyrowitz.

CLASS 26.

Grand Prix—John A. Roebling's Sons Co.; Rowland Telegraphic Co.; Western Electric Co. *Gold Medal*—Edison Phonographic Works. *Silver Medal*—American Wireless Telegraph Co.; Herzog Teleseme Co.; International Cable Directory Co. *Bronze Medal*—American Electric Telephone Co.; Dicke Tool Co.; Farr Telephone & Supply Co.; Foote, Pierson & Co.; Huebel & Manger Mfg. Co.; Partrick, Carter & Wilkins; Safety Insulated Wire & Cable Co.; Sprague Electric Co.; Standard Telephone & Electric Co.; Stromberg-Carlson Telephone Co.; Telephone Mfg. Co.; Western Telephone Construction Co. *Honorable Mention*—H. Anderson; Insulating Saddle Staple Co.; Mathias Klein & Son; Pennsylvania Electric Co.; Viaduct Mfg. Co.

CLASS 27.

Gold Medal—Weston Electrical Instrument Co. *Silver Medal*—Ritter Dental Mfg. Co. *Bronze Medal*—American Electrical Heating Corp'n; William Marshall; E. B. Meyrowitz; Sempire Clock Co.; Wagner Electric Mfg. Co. *Honorable Mention*—Abbot Electric & Mfg. Co.; American Electric Heating Co.; American Electrical Specialty Co.; Eldridge Electric Mfg. Co.; Gold Car Heating Co.; Gordon Battery Co.; Hadaway Electric Heating & Engineering Co.; McCay Engineering Co.

Following are given some notes concerning Paris exhibitors which were crowded out of the September issue by lack of space.

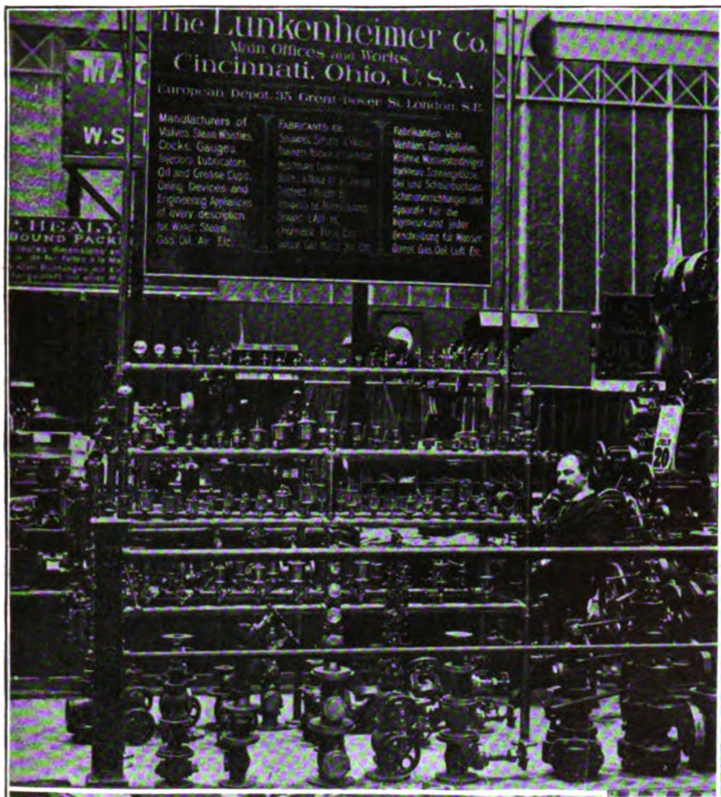
QUEEN & CO., Philadelphia, interested many visitors in their instrument exhibit.

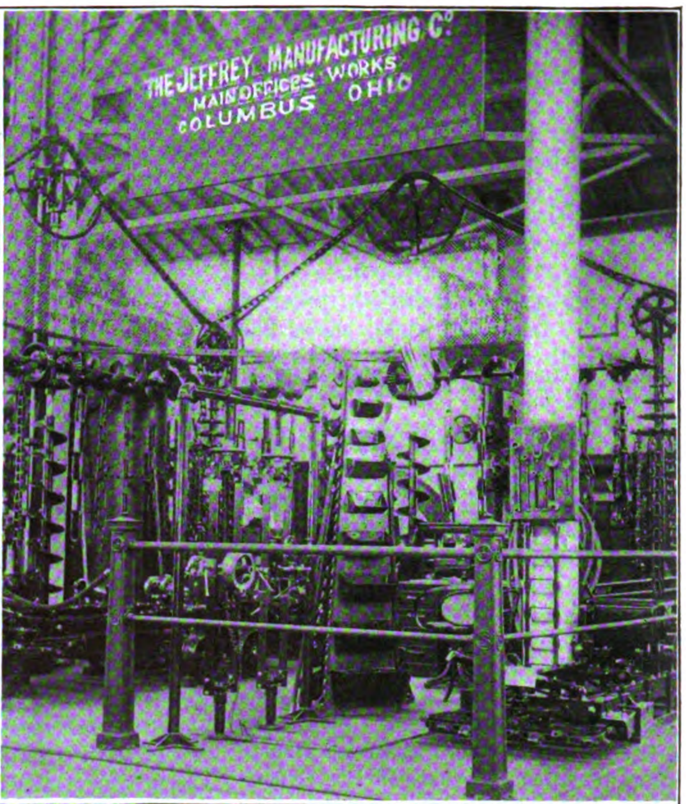
THE AMERICAN ELECTRIC SPECIALTY COMPANY, New York, has a neat display of its instruments.

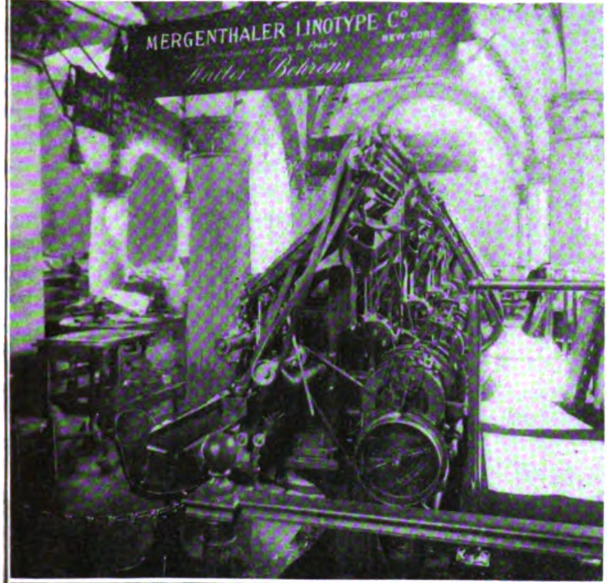
THE PITTSBURG TRANSFORMER COMPANY, Pittsburg, shows a line of its transformers in the Electricity Building.

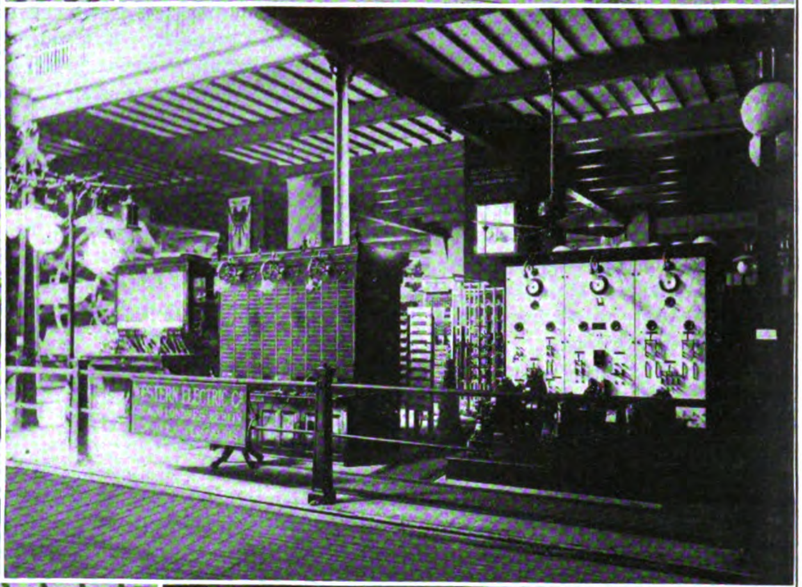
THE KENNEDY VALVE COMPANY, New York, has an exhibit of its valves in one of the cases of the collective exhibit.

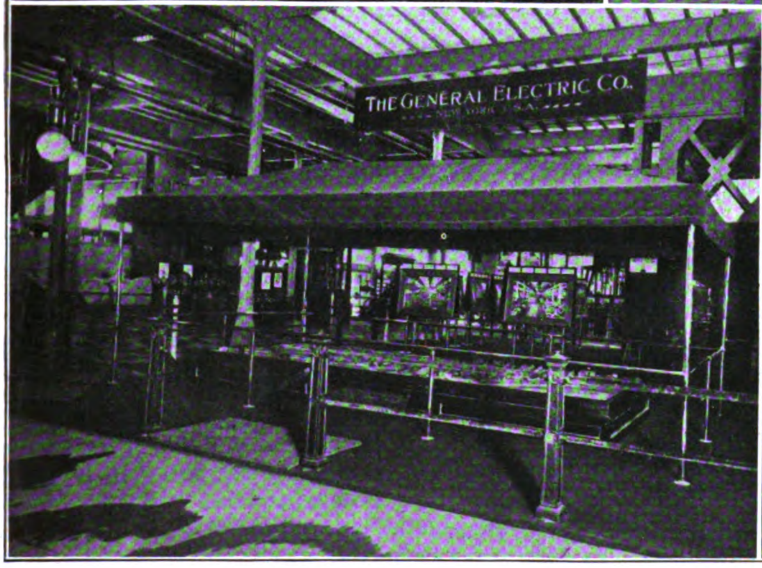
THE WESTON ELECTRICAL INSTRUMENT COMPANY, Newark, N. J.,

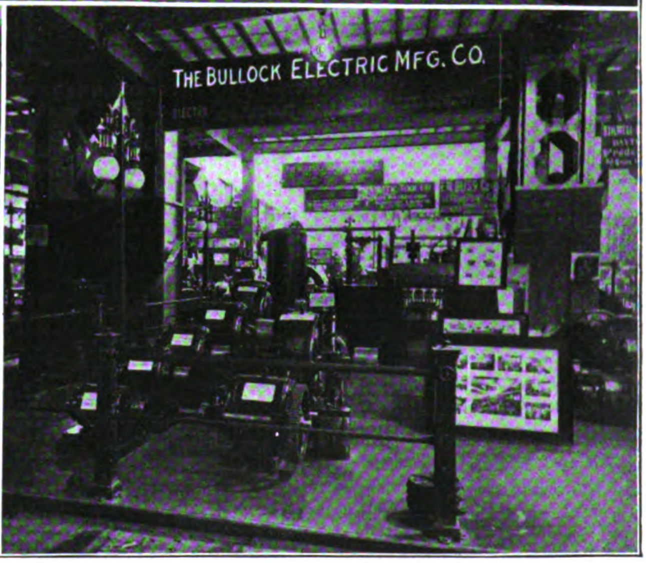

The Lunkenheimer Co.
Main Offices and Works,
Cincinnati, Ohio, U.S.A.
European Depot, 35 Great Tower St. London, S.E.
Manufacturers of Valves, Steam Whistles, Cocks, Gauges, Injectors, Lubricators, Oil and Grease Cups, Oiling Devices and Engineering Appliances of every description for Water, Steam, Gas, Oil, Air, Etc.


THE JEFFREY MANUFACTURING Co.
MAIN OFFICES WORKS
COLUMBUS OHIO


MERGENTHALER LINOTYPE Co
NEW-YORK
Walter Behrens


WESTERN ELECTRIC Co


THE GENERAL ELECTRIC CO.


THE BULLOCK ELECTRIC MFG. CO.

LUNKENHEIMER EXHIBIT.
LUNDELL MOTOR AND LINOTYPE MACHINE.
GENERAL ELECTRIC EXHIBIT.

JEFFREY EXHIBIT.
WESTERN ELECTRIC EXHIBIT.
BULLOCK EXHIBIT.

makes an effective display of its well-known instruments.

THE HARDY LAMP COMPANY, Pittsfield, Mass., exhibits its series and 220-volt lamps, miniature and decorative lamps and candelabra.

THE NORTON ELECTRICAL INSTRUMENT COMPANY, Manchester, Conn., sent a line of their instruments which excited much favorable comment.

THE JEFFREY MANUFACTURING COMPANY, Columbus, Ohio, shows one of its electric coal mining machines driven by a 20-h.p. motor; also a No. 1½ electric coal drill.

THE MONTAUK MULTIPHASE CABLE COMPANY, New York, showed samples of its specialties which interested many foreign visitors.

THE LUNKENHEIMER COMPANY, Cincinnati, Ohio, exhibits a large collection of its well-known brass specialties, including valves, lubricators, injectors, oil cups, whistles, safety valves, etc.

I. P. FRINK, New York, has two of his handsome reflectors on the gallery wall of the Electricity Building in addition to others installed elsewhere in the Exposition buildings by the Government.

PARTRICK, CARTER & WILKINS, Philadelphia, have an interesting line of their well-known bells, annunciators, hotel and house goods displayed on the wall of the gallery of the Electricity Building.

THE HOLOPHANE GLASS COMPANY, New York, has one of the most beautiful exhibits—a number of its globes and shades being grouped together in a most attractive fashion. Holophane globes are also in use on the service lamps of the United States exhibits.

THE C & C ELECTRIC COMPANY, New York, has one of its 16-h.p. motors operating the machine tools, about twenty in number, in the exhibit of the Pratt & Whitney Company. A 30-h.p. C & C motor also furnishes power for about thirty machines comprised in the exhibit of the E. W. Bliss Company, at Vincennes.

THE SPRAGUE ELECTRIC COMPANY, New York, has on exhibition in the American Publishers' Building Lundell motors operating a gang of five Linotype machines; also a Sprague belted motor driving a Harris press. The Sprague Company also exhibited in the Electricity Building the latest types of its interior conduit.

THE BRISTOL COMPANY, Waterbury, Conn., in addition to furnishing one of its recording pressure gauge and recording voltmeters for use on the switchboard of the United States Machinery Hall, at Vincennes, has an exhibit in the Electricity Building gallery of its recording instruments for pressure, temperature and electric current.

THE LUNKENHEIMER COMPANY, Cincinnati, Ohio, makes a very prominent exhibit of their numerous specialties—the newest of which is a line of injectors. The company has been so busy filling orders for these in the American market that they have been unable to do much in the way of supplying them abroad. A full assortment is now in the company's London office and a heavy foreign trade in these specialties is confidently anticipated.

THE WAGNER ELECTRIC MANUFACTURING COMPANY, St. Louis, has one of its marble switchboards on exhibition, with several of its well-known types of instruments made for either the front or back of the board. They are exceedingly handsome station instruments and give absolutely dead beat indications. The display includes a type F wattmeter; two illuminated dials, back of the board type, with narrow front; and wide front type H voltmeter with illuminated dial. The company also shows a 3-h.p. single-phase self-starting motor to run at 1500 r.p.m.

THE WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, Pittsburg, is entitled to, and has received, the cordial thanks of the exhibitors in the American Publishers' Building, who secured the necessary current for light and power in it after it opened only by the active intervention of Messrs. Arthur Warren and Maurice Coster of the Westinghouse Company. Through the energetic co-operation of these gentlemen the plan was carried out of drawing on the Westinghouse street-railway plant at Moulineaux. The lights were run on its 5000-volt three-phase current taken through a static transformer. One of the most interesting contributions to the United States portion of the social-economic exhibits of various countries was a handsome set of photographs of the Westinghouse shops at Pittsburg. The motor cars of the Exposition Third-Rail Road are each equipped with four Westinghouse 30-h.p. motors, as well as with the usual Westinghouse controllers. The road and the moving sidewalk are driven by an induction Westinghouse motor of 850 horsepower, said to be the largest ever built, taking 5000 volts direct. There is also a reserve plant of the same size and nature in the Westinghouse Exposition plant.

THE IRON-CLAD RESISTANCE COMPANY, Westfield, N. J., shows among the collective exhibits in the gallery of the Electricity Building a number of its universal interlocking theater dimmers, stand field rheostats in different sizes, and a reversing crane motor controller with renewable contact switch, and its special heavy duty resistances.

THE WESTERN ELECTRIC COMPANY has probably the most comprehensive exhibit in the American electrical section of the Electricity Building. It includes a telephone exchange of 18,000 lines, shown in operation. The telephone exchange is on the common battery system, the operating current being furnished by a storage battery of 11 cells. These cells are charged from the 220-volt distributing mains of Electricity Building by means of two twin motor charging generators, furnishing 40 amperes at from 20 to 30 volts, between which limits the pressure can be regulated. A number of telephone instruments have been distributed by the company in the American section of Groups IV. and V., both on the ground floor and in the gallery, and also in the American Machinery Building at Vincennes. The exchange is connected to the central exchange of Paris by three lines, so that exhibitors in the American section have telephonic connection with all the subscribers throughout Paris. Besides the exchange, there is shown an exhibit of wall, desk and table telephone instruments, for the common battery system, and also magneto instruments for exchange and private lines. In the line of telegraphy there is shown a complete set of instruments, with a fifty-line switchboard, as used in New York. The exhibit also contains a complete line of fire-alarm apparatus, in working position, and consisting of both key and keyless boxes. A complete line of street railway line supplies and cables and cable tools are also shown. An electric lighting and motor distribution plant is also shown in operation. It consists of a 75-kw. 110-volt generator, directly driven by a motor of the same type, but wound for 220 volts. The exhibit also includes power motors in the three types manufactured by the company, viz.: the open type, semi-encased and encased; enclosed arc lamps for various circuits, to run on singly or 110 volts, to run two in series on 220-volt circuits and to run on alternating currents; two finished armatures; fan motors of both desk and bracket types; also two styles of ceiling fans. Among the most interesting features of the exhibit were the plaster models of the company's Chicago and New York factories. The company distributes from its space catalogues in English, French, Spanish and German.

THE GENERAL ELECTRIC COMPANY has its exhibit on the ground floor of Electricity Building, which contains a model of its three factories, made to a scale of 20 ft. to one inch, showing the complete works of the company, each of the three factories being fenced in separately. The ground is constructed in sheet zinc, cut away where the buildings are located. The buildings are of sheet copper with mica windows. The model is lighted from below with three rows of 18 incandescent lamps each, and from above by three rows of eight lamps each. Each of these rows of lamps, above as well as below, is controlled by a separate switch. The area represented by the models amounts to 174 acres, and the buildings have a floor space of two million square feet. The General Electric Company also shows interior photographic views of its works, and views of some of the larger of its installations. The photos are of extraordinary size—36 x 24 ins.—the largest plate made in America, and depict a view of the big machine shop in Schenectady, the largest in America, being 650 ft. long by 156 ft. wide, and having a total floor space of 143,000 sq. ft.; one view of the big foundry in which 750,000 lbs. of iron

American Electrician.

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ALTERNATING-CURRENT MOTORS IN A LARGE TEXTILE MILL.

ELECTRICAL TRANSMISSION OF POWER AT PELZER, S. C.

BY A. F. M'KISSICK.

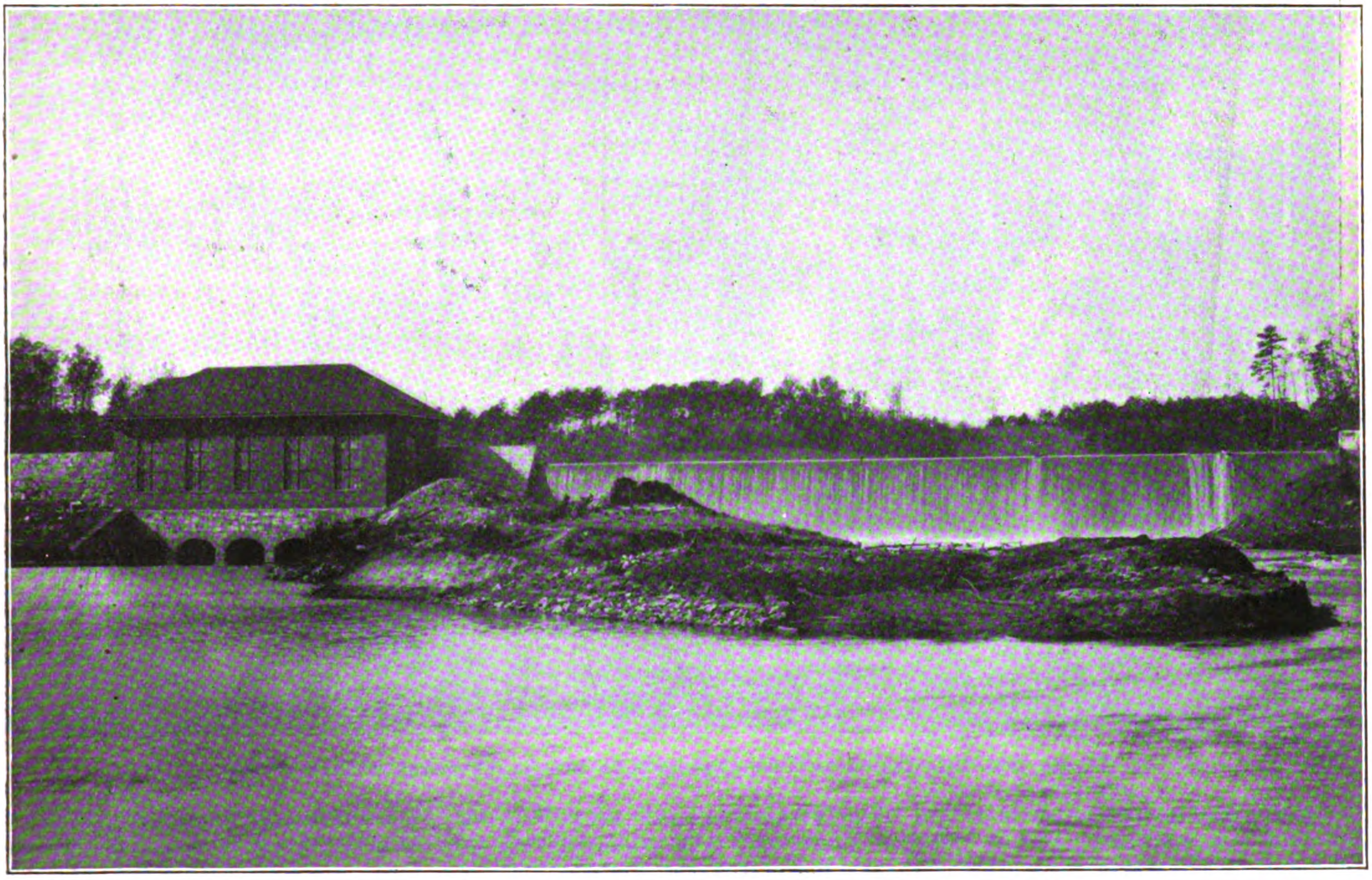


FIG. .—SHOWING THE UNOSTENTATIOUS APPEARANCE POSSIBLE TO AN IMPORTANT POWER GENERATING STATION.

The first case of adoption of electricity in the South as a means of transmission of power for a cotton mill was that of the Columbia Mills at Columbia, S. C., early in 1894. Prior to that time the power for cotton mills was produced either from steam engines or turbines and transmitted by means of belts or ropes. In a great many towns and cities in the South the question of water or steam was not considered for the reason that there was no available water-power convenient. Before the fact was established that power could be transmitted successfully by electricity a great many water-powers in the South were considered unavailable on account of the distance of the water-power from the railroads, or the lack of a convenient and satisfactory site for a mill that would not require excessive excavations and foundations. But when electrical transmission of power became no longer an experiment, and the question of distance not such an item, a large increase in the development of water-powers resulted.

One of the most interesting and important water-power developments in the South within recent years is that accomplished by the Pelzer Manufacturing Company at Pelzer, S. C., a short time after the starting of the Columbia Mills. This company at the beginning of 1894 had in operation mills Nos. 1, 2 and 3, aggregating 52,000 spindles, mills Nos. 1 and 2 being driven by water wheels, and mill No. 3 by a 450-h.p. steam engine. It was determined at this time by the management to build another mill of 68,000 spindles capacity. For the operation of this mill it was decided to make use of a water-power 2½ miles lower down the river, and transmit the power by electricity to the new mill, which was to be located on a level site near the old mills, and thus gain the very great advantage of having all the mills together; at the same time it was planned to develop sufficient power to enable mill No. 3 to be driven by a motor instead of a steam engine. The contract for the whole electrical installation, including three 1000-h.p. generators, one 450-h.p. synchronous motor for mill No. 3, and all the motors, transformers and other electrical apparatus for mill No. 4, was awarded to the General Electric Company.

POWER HOUSE AND DAM.

To obtain the necessary fall and at the same time a sufficient reservoir for the storage of water, a dam 32 ft. high and 450 ft. long was built across the Saluda River. This dam has since been added to so that there is now a fall of 39 ft. The face of the power house is located on the line of the dam, as shown in Fig. 1. The power house is provided with wheel pits and feeders for five pairs of horizontal wheels, each pair capable of developing approximately 1200 horse-power. Three pairs of wheels with direct-connected generators have already been installed. Fig. 2 shows a view of the interior of the power house. The generators are the General Electric standard revolving-armature three-phase type, of 750 kilowatts output at 3600 volts, giving 60 cycles per second, and the turbines are the Victor, made by the Stilwell-Bierce & Smith-Vaile Company, Dayton, Ohio, with Giesler electro-mechanical governors. The generators are operated in parallel and feed the lines direct without the intervention of transformers. In connecting these machines in multiple, the use of a synchronizing device, such as lamps, is avoided, although the switchboard is equipped with phasing lamps; paralleling is accomplished by connecting all three machines together before starting up, and then gradually speeding up the machines and exciting them as the speed goes up. This operation is performed very quickly and is very satisfactory.

A traveling crane of 15 tons capacity is provided in the power house, the track for which is supported upon pilasters built upon the interior of the power-house walls.

The line consists of eighteen No. 00 bare copper wires, the wires of each phase being on an individual cross-arm. On the top cross-arm are strung two "buckthorn" wires for lightning protection, these being grounded at every fourth pole. The wires on the bottom cross-arm are the telephone wires, which are transposed at every sixth pole to nullify induction troubles as much as possible.

The synchronous motor operating mill No. 3 receives current direct from the line and is self-starting. It is connected to the main shaft of mill No. 3 by means of a rope drive, and this shaft is so arranged that the whole load can be thrown on either the motor or the engine, or the load divided between the two. The saving of coal, oil and labor by the use of this motor is a considerable item.

Mill No. 4 is equipped throughout with motors, and for its operation depends entirely on electrical transmission of power. There are in use in the mill twenty-eight motors, not including two small motors which drive blowers for cooling the transformers. The wires lead into a tower at the corner of the building, where the lightning arresters at this end of the line are located. From this tower the wires go underground in a tunnel to the transformer room, where are installed three 275-kw. transformers and six 165-kw. transformers. These transformers are artificially cooled by an air blast from two fans driven by 10-h.p. motors. In addition to this ventilation there is in operation a suction fan which draws out the hot air from the transformer room.

From the transformer room wires lead to each motor, which are distributed through the mill as follows:

Basement.—One 50-h.p. motor, operating cloth-room machinery and elevators, and one 50-h.p. motor operating aerophor pumps and heating apparatus. First floor—Four 75-h.p. motors operating picker-room machinery, and four 130-h.p. motors operating 1580 looms on the first and second floors. Second floor.—One 130-h.p motor operating 28 spinning frames. Third floor—Three 130-h.p. motors and two 30-h.p. motors operating carding-room machinery. Fourth floor—Nine 130-h.p. motors and four 50-h.p. motors operating spinning frames, warpers and spoolers. In addition to the motors here enumerated there are three small induction motors driving pumps, and one driving the machinery in the foundry.

Fig. 3 gives a view of the motors in the spinning room, which shows how they are attached to the ceiling. It has been found necessary in the spinning and carding rooms to use the squirrel-cage type of motor on account of the excessive lint and flyings in those rooms. This style of motor, while it takes a very heavy starting current, after it is once started gives good satisfaction. All the other mo-

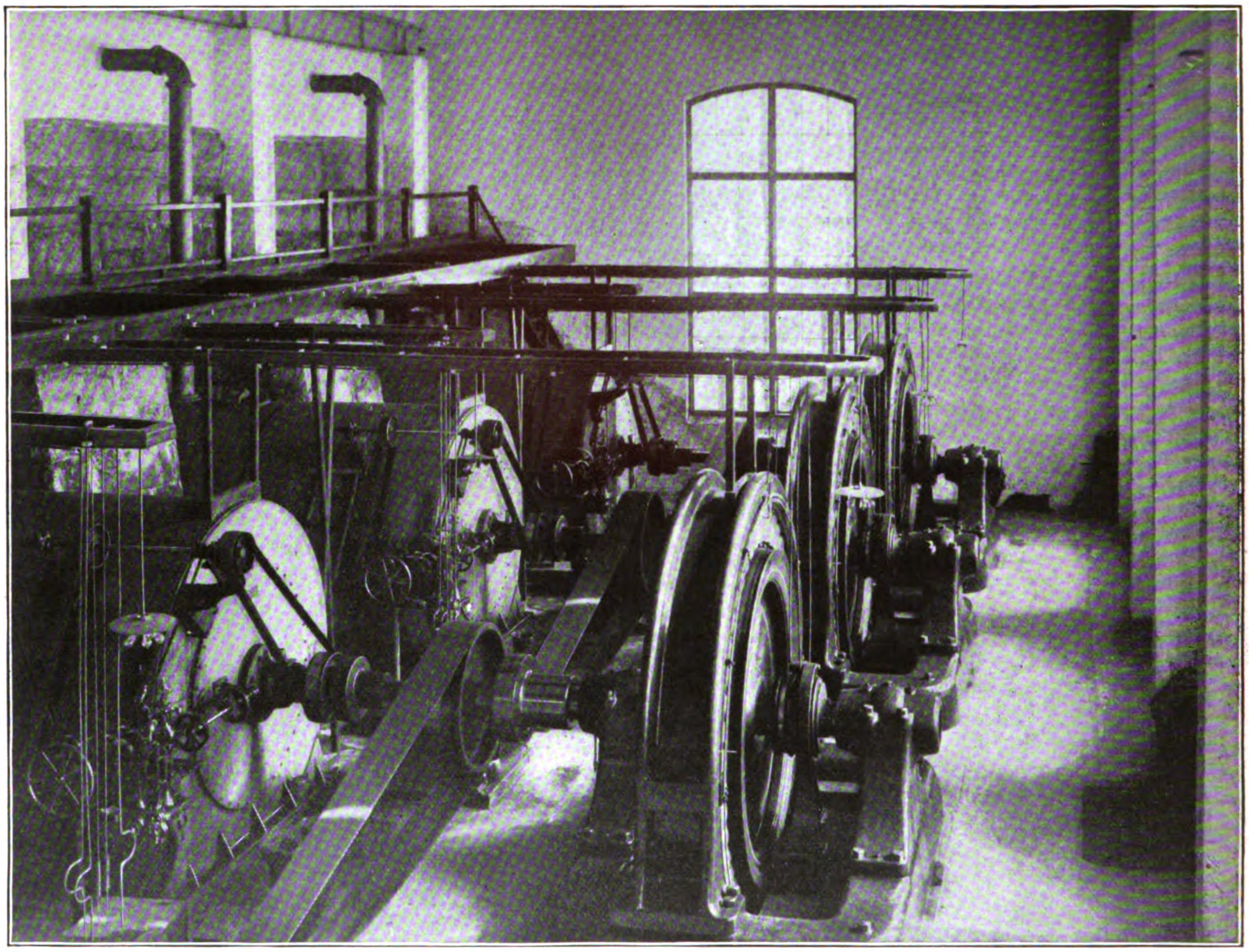


FIG. 2.—INTERIOR OF GENERATOR ROOM OF THE PELZER POWER HOUSE.

tors in the mill are of the clutch type, with variable resistance in the circuit of the rotating secondary element. These motors are cleaned daily, being blown out with compressed air.

In order to increase the power factor of this plant a 400-kw. rotary condenser, which is simply an over-excited synchronous motor running free, was installed during the summer of 1899. This condenser motor is connected in multiple to the secondary 220-volt mains so that by its use the wattless currents in transformer line and generators are reduced, thus giving a lower temperature in the transformers and the generator and less inductive drop in the line; the reduction in inductive drop allowed the generator e.m.f. to be reduced 90 volts with the same impressed e.m.f. at the motor terminals as formerly. The reduction of the current output varied from 8 to 11 per cent. This condenser motor is self-starting from rest, and after once being started and adjusted needs no attention. Repeated tests have shown that this condenser has no effect on the turbine gate opening; that is, the amount of power it saves by the reduction of heat losses in the transformers, line and generators, and in the diminished exciting power required for the generator, practically balances the power required for the operation of the condenser motor itself. The exciter of the condenser motor is on the same shaft, so that the machine is a very simple one and works very satisfactorily. Its capacity as a condenser can be quickly varied to suit the character of the load. When the synchronous motor at mill No. 3 is running alone, there is absolutely no need for the condenser motor. The power factor of this plant with full load on, without the condenser motor, is 86 per cent, and with the condenser it is 94 per cent. The following readings are given to show the effect of the condenser motor:

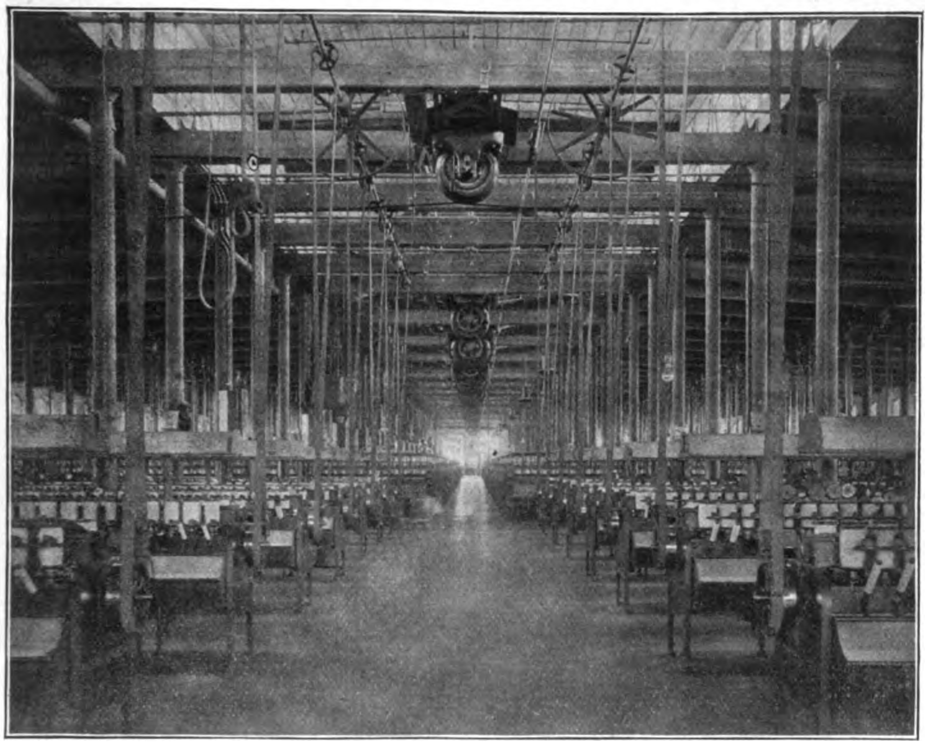


FIG. 3.—SPINNING MACHINERY DRIVEN BY CEILING MOTORS.

	Generator e.m.f.	Current output.
Without condenser	3780	435
With condenser	3690	402

In the above test the e.m.f. at the motor terminals was kept constant.

It was found necessary, on account of the low water in summer, to supplement the water-power at mills Nos. 1 and 2 with steam-power, and bearing in mind the fact that mill No. 4 would also suffer from low water, it was decided to put in at mills Nos. 1 and 2 a steam engine of sufficient size to supplement the water-power of mills Nos. 1 and 2, and also to drive a 1000-h.p. generator for assisting mill No. 4 during low-water periods. This generator is a General Electric revolving-field alternator and feeds into the line system, being put in phase by means of lamps. An important feature is that this generator can be made to run as a motor, so that the installation of the machine connected mills Nos. 1, 2, 3 and 4 together, so far as power is concerned.

One of the interesting points noted in connection with the working of the plant is the difference in power required in summer and in winter-time. In summer-time, with the maximum head of water, and all four mills running on water, there is between 350 and 400 horse-power to spare; but in the middle of winter, with the maximum head of water at each pond, there is always, in the early morning, a deficiency in power, causing the speed to be a few revolutions slow. This deficiency gradually diminishes, until finally, toward the middle of the day, there is actually a surplus of power. So that it is found economical, leaving out all questions of health or comfort, to keep these mills well heated in winter. In these comparisons the load in each case was practically the same, including lamps and motors.

Since the addition of machinery to mill No. 4, two years ago, it was found that even with the maximum head of water the power house was unable to drive mill No. 4 and mill No. 3. This trouble was obviated, however, by utilizing the surplus power of mills Nos. 1 and 2 (about 250-horse-power) by means of the reserve generator, which enabled everything to be driven primarily with water-power. In times of low water the reserve engine at No. 3 mill is operated, and also the large one under mill No. 1, which is connected in with the turbines during mills Nos. 1 and 2.

"BUCKING" OF LARGE SHUNT-WOUND MOTORS.

The action of shunt-wound motors of over 100 horse-power is not as familiar to most electrical men as the action of smaller machines. The reason for this is, of course, that there are comparatively few large shunt motors in use. At Kansas City the Metropolitan Street Railway regularly operates a 300-kw. motor to run cable machinery pulling about 24,000 ft. of cable. There are two motors of this capacity, one being held in reserve.

When the company built its new Central Avenue power house it was figured that considerable money could be saved by abandoning a rather uneconomical steam plant then running the Ninth Street cable, and operating the cable by electric motors supplied from the large and economical Central Avenue electric plant; the motors were accordingly installed. When they were started, however, a serious difficulty arose. The load imposed by the cable was widely variable, and when sudden heavy loads were thrown on, the motor promptly responded by "bucking" and flashing viciously at the commutator. The "bucking" of a large motor is something not to be forgotten easily, and is such a severe strain on the armature that the electrical driving of the cable would have been necessarily discontinued had a remedy not been found. The remedy was simply to use a series winding on the field magnet of such direction as to strengthen the fields with increasing load on the motor. The result is that the motors run almost sparkless, with no trouble from bucking.

Chas. Grover, electrician of the Metropolitan Street Railway Company, explains the phenomenon of "bucking" of large shunt motors in this way: The brushes are, of course, set at the sparkless position for light loads. When the sudden heavy load comes on the great rush of armature current tends to overbalance the field magnetization (which latter remains, of course, constant) to such an extent that the field flux is very much distorted; so much so, in fact, that the effect is just as if the brushes were shifted away from the neutral point very suddenly, and the result is that the machine "bucks."

Engines and Generators at the Paris Exposition

In France there are many manufacturing concerns which do not confine their operations to a single line of products, but devote themselves to complete equipments, including all apparatus required for electrical installations. A noteworthy example of this method of doing business is found in the Compagnie de Fives-Lille, of Paris, whose principal factory is in the town of Fives-Lille, and who are exhibiting—among other machinery—boilers and a combined engine, and alternator, the latter supplying current to the Exposition. In the case of many firms the commencement in business was the manufacture of spinning and weaving machinery, which formed a very important part of the industry of the country. An extension was then made into engine building, then boilers, and at a later date the natural sequence of this blanket policy brought them into the electrical field.

The boilers of the Fives-Lille Company at the Exposition are of the semi-tubular type. Steam is supplied at a pressure of 150 to 160 lbs. to the mains, which are carried on the roof supports of the boiler room and deliver to the equalizers, whence the steam passes through pipes laid in tunnels to the engine room.

The engine shown by this company is capable of developing 1200 indicated horse-power; it has cross-compound cylinders 27½ ins. and 51$^{3}/_{16}$ in. in diameter respectively, and 55⅛ ins. stroke. The usual practice of steam-jacketing the cylinders is followed. Corliss valve gear is used, with exceptionally heavy connecting rods to the valve mechanism. The eccentric rods are attached to levers, by means of which the travel of the valve connecting-rod is increased to nearly double that of the eccentric. Jet condensers are placed below the engine-room floor, and the air pump is driven by a link and lever operated from the crosshead of the low-pressure piston rod.

The engine drives a three-phase, 800-kw., 2200-volt flywheel alternator, running at about 79 r.p.m., which, since there are 76 poles, gives a frequency of 50 cycles per second. The flywheel carrying the field magnets weighs complete about 35 tons. The pole-pieces are made of laminated steel, with paper insulation between the laminae, and are secured to the rim each by two bolts, which screw into rectangular steel bars passing transversely through the sheets. The bore of the armature is nearly 20 ft. (6 meters) and the air-gap is 7 millimeters (0.276 in.). Exciting current is brought from an outside source, at 220 volts; but there is sufficient room on the shaft on each side of the flywheel to put in an exciter, if it were desired to adopt this method, which is used by several European builders.

Considerable protection is afforded to both the field and the armature coils by overhanging segments of iron bolted to the armature frame. This frame is in four parts bolted together, the bolts at the vertical joints being adjusted through handholes, so that the exterior is uniformly smooth and neat. Accurate centering of the armature with the field magnet is obtained by supporting the armature frame on adjustable screws which may be locked in position.

In the Dutch section a very complete exhibit is made by Stork Brothers & Company, of Hengelo, and Electrotechnische Industrie (formerly William Smit & Company) of Slikkerveer, Holland. The principal exhibit is a cross-compound 600-h.p. horizontal condensing engine, direct-connected to a 330-kw. 10-pole direct-current generator, running at 115 r.p.m. The engine cylinders are 20⅞ ins. and 34$^{7}/_{16}$ ins. in diameter, for high and low pressure respectively. The air pump, vertical and single-acting, is worked from a lever connected to an extension of the low-pressure piston rod behind the cylinder.

Double-seated vertical valves admit steam, those for the high-pressure cylinder being controlled by a Dorfel-Broll governor which gives admission from 0 to 60 per cent of the stroke. Superheated steam is used for this engine, and the receiver contains a number of tubes through which a certain quantity of the steam is allowed to pass on its way to

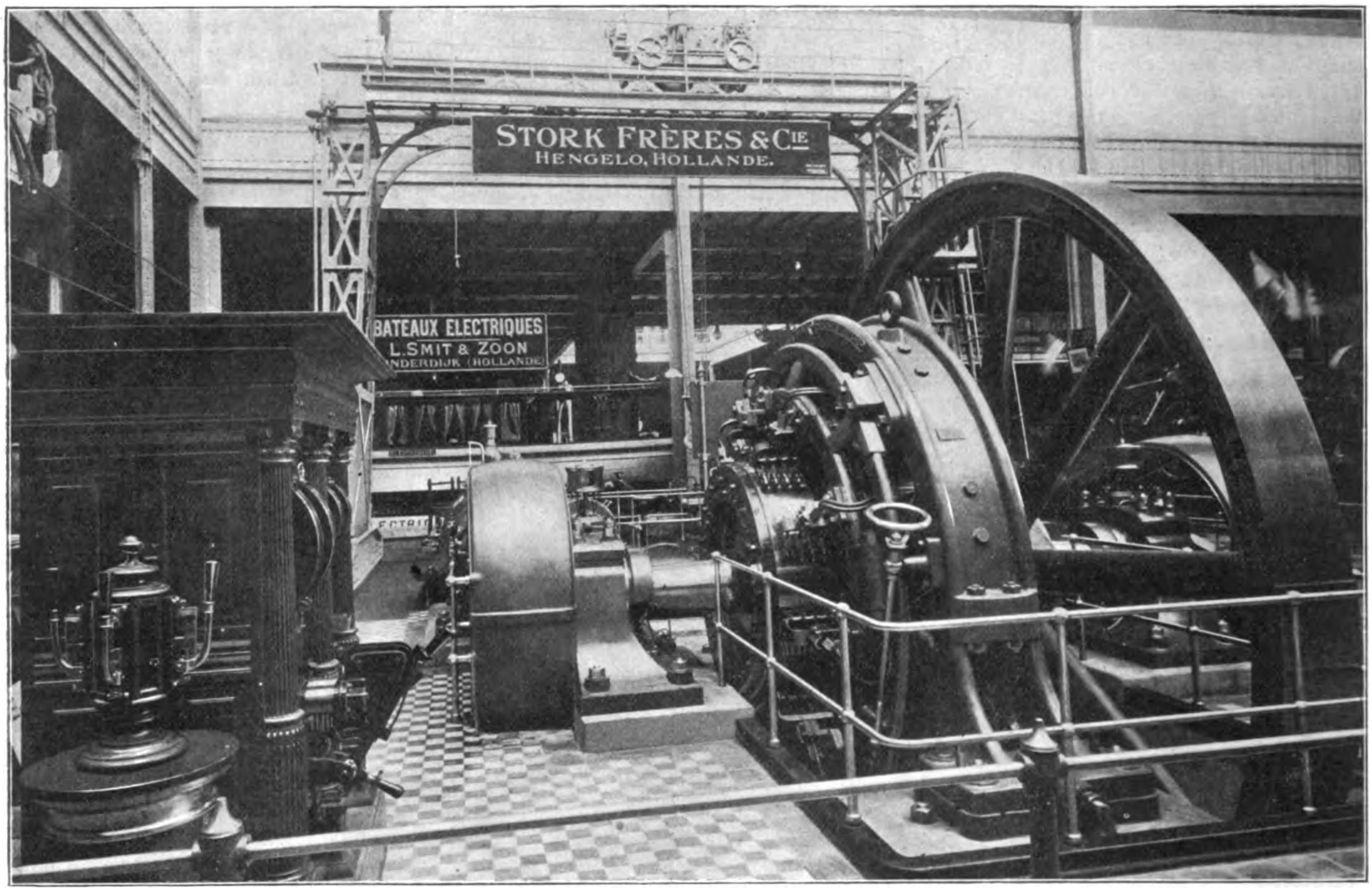
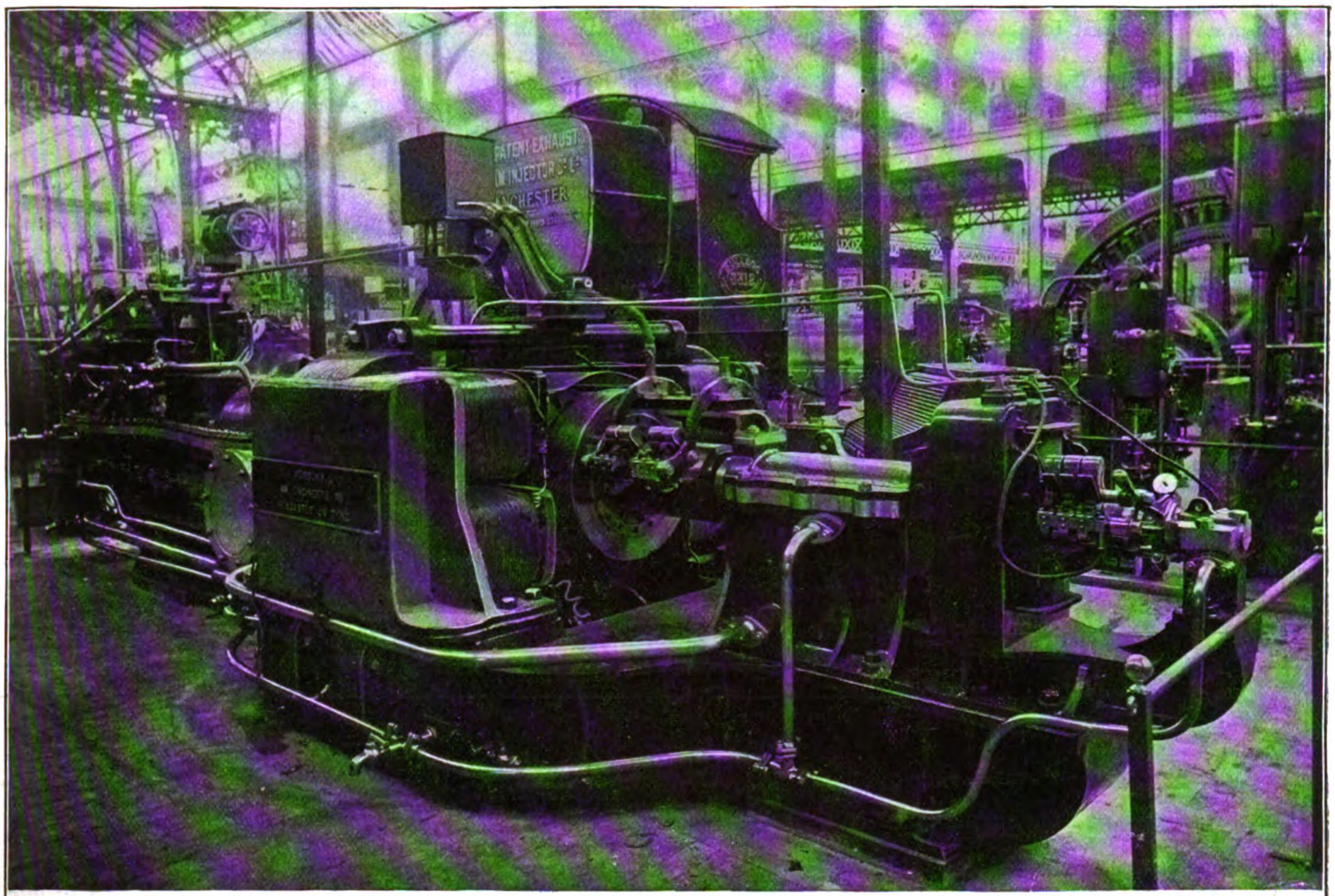


FIG. 31.—STORK BROS. 600-H.P. CROSS-COMPOUND ENGINE DRIVING ELECTROTECHNISCHE DIRECT-CURRENT GENERATOR.


PATENT EXHAUST
INJECTOR Co Ld
MANCHESTER

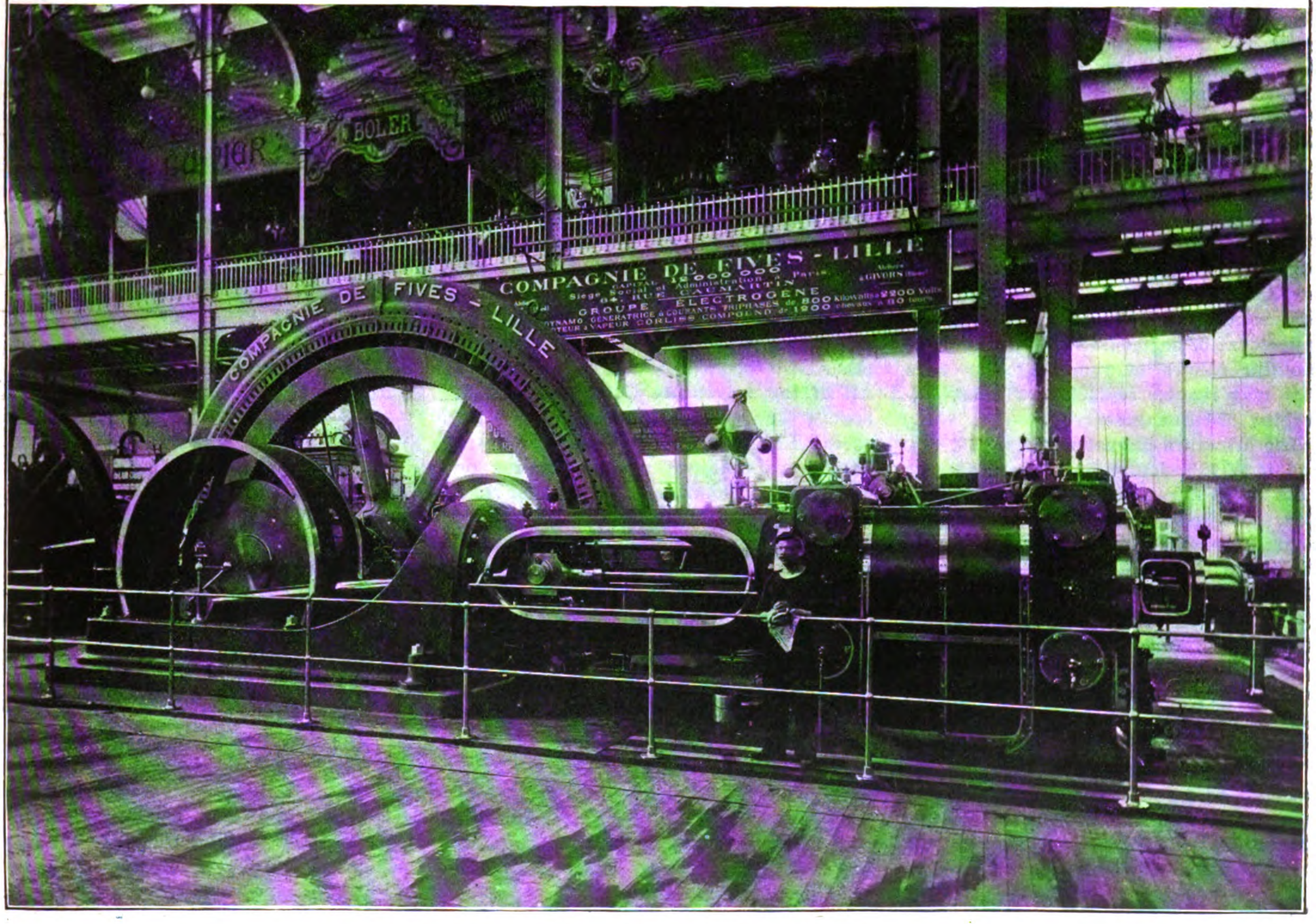

BOLER
COMPAGNIE DE FIVES-LILLE
GROUPE ELECTROGENE
COMPAGNIE DE FIVES - LILLE

FIG. 2.—PARSONS STEAM TURBINE AND 500-KW. FOUR-POLE ALTERNATOR.
FIG. 3.—FIVES-LILLE 1200-H.P. CROSS COMPOUND ENGINE DRIVING THREE-PHASE ALTERNATOR.

the high-pressure cylinder, thus heating the high-pressure exhaust to about 200° Centigrade. The engine is intended to work with steam at 150 lbs. pressure.

The dynamo is shunt-wound in order to give smoother service when running in parallel with others for the Exposition lighting. The output is 600 amperes at 550 volts. The field yoke is of cast steel, round pole-pieces being held in place by bolts through the rim, and the field coils secured by the spread of the pole tips. A drum-wound slotted armature is used, built up of soft iron discs, each in eight segments, insulated one from another by paper and dovetailed to a cast iron spider, so that no bolts pass through the armature core. The spider is a separate casting from the hub, to which it is fastened by eight keys, one in each of the eight radial arms of the hub, and it is in one piece, while the hub is in halves bolted together and keyed to the shaft. The hub also carries the commutator frame, which is bored out to fit closely and is keyed and held by a flange ring against working off. An ingenious arrangement of segmental ends to the commutator allows of removing any bars that may require replacing, without disturbing the remainder.

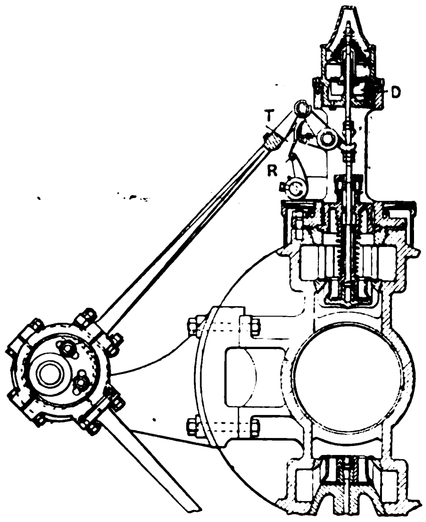


FIG. 4.—VALVE GEAR OF LANG ENGINE.

The armature diameter is 6 ft. 6¾ ins. and it is 15¾ ins. wide. There are 224 slots with micanite troughs for insulation, each slot having four conductors 20 millimeters (.7874 in.) deep by 3 millimeters (.118 in.) thick. A barrel form of winding is employed; the conductors at the back end are bent instead of being connected by soldered joints. Hard drawn copper is used for the commutator, in which there are 448 segments, with an outside diameter of 4 ft. 11¼ ins. and a brush tread 12 ins. wide.

In each set there are four carbon brushes, or forty in all. A particularly strong and effective method of making contact between the brush-holder frames and the main rings consists of a heavy cable tip of rectangular bar form which is held in place by a shoe bolted down by four bolts.

A handsome switchboard stands near this generator, made by Hofstede, Crull & Willing, of Hengelo, Holland, in the style of an old Dutch cabinet in carved oak. The two panels are of polished slate and are provided with a set of Weston edgewise instruments; also with an automatic underload cut-out and a heavy main switch capable of breaking full-load current, with magnetic blow-outs on each pole. The back of the switchboard is closed by a door which is lined, as is the whole inside of the cabinet, with slate. At the side of the switchboard is a pillar with a slate top carrying contacts for a field regulator, the resistances being placed within the pillar.

The Electrotechnische Industrie also exhibits motors of various designs, marine direct-connected engine-generator sets, transformers, and an electric accumulator launch which will be described in an early issue. We are indebted for many courtesies to Mr. F. Schouten, electrical engineer of the company, and its representative at the Exposition.

In the July number of the American Electrician we presented an illustration of a cross-compound Lang engine driving a 1200-kw. Ganz three-phase alternator. We are enabled now to supply the principal details relating to this interesting engine. Figs. 6 and 7 herewith give semi-sectional elevation and plan views of one of the pair of engines and alternator, and Fig. 4 illustrates the details of the valve gear. The engine is rated at 1900 horse-power and runs at 125 r.p.m. As the engravings show, each cylinder is provided with a tail rod, which drives a single-acting air pump installed below the floor level.

The governor is an enclosed fly-ball arrangement mounted horizontally on the secondary shaft of the engine, which also carries the valve-operating eccentrics. The governor controls the cut-off in the high-pressure cylinder only, that of the low-pressure cylinder being fixed. There are four eccentrics for each cylinder, two operating the exhaust valves and the other two operating the steam valves. All of the valves are Collmann "double beat." The exhaust valves are directly operated by their eccentrics and the steam valves are equipped with a tripping or releasing mechanism of the roller and pallet type and Collmann dash pots. Fig. 4 shows the principle of operation of the valve gear, although the valve illustrated there is not the same in every detail as that used on the particular engine under discussion. In this engraving, D is the dash pot, R is the tripping roller, the position of which is varied by the governor so as to throw the pallet, T, at different points in the piston stroke, according to the requirements of the load; the pallet, T, of course, when thrown disengages the eccentric gear from the rock-shaft that raises the valve and allows the latter to seat under the influence of its coil spring.

Live steam passes through the jacket of the high-pressure cylinder on the way to the steam chest, and the low-pressure cylinder is similarly heated by the intermediate receiver steam. The cylinder heads are made in the form of jackets and arranged so that steam can be admitted or not, as desired.

The generator driven by this engine is a three-phase alternating-current machine with a flywheel field magnet carrying 48 poles and supplying current at 2200 volts and 52 cycles per second. The diameter of the air gap is 13 ft. 7½ ins.; the weight of the field magnet flywheel complete is 22¼ tons. The maximum rise of temperature in any part of the alternator is 35° C. (63° F.).

An exhibit of special interest and importance to electrical engineers is one comprising two Parsons steam turbines direct-coupled to generators. The larger unit is a 4-pole alternator of 500 kilowatts output, and the smaller one is a bipolar direct-current dynamo of 70 kilowatts output. Both machines are driven at the rate of 3000 r.p.m. The 70-kw. turbine-generator is mounted upon a base forming a surface condenser, so that the whole steam plant is self-contained. One of the features contributing to the high economy secured with this turbine is the return of the condensed steam directly to the boiler; since none of the moving parts in the cylinder touch against stationary parts, no cylinder oil is required, and the water of condensation remains pure. Another noteworthy feature of the turbine is that it is not necessary to provide foundation bolts, as there is no tendency for the machine to creep, and it may be placed on stone blocks, where its own weight will keep it in place.

The commutator of the direct-current machine is supported at its center by a steel ring, to keep the segments from flying out. Additional collecting surface is obtained by turning V-shaped grooves throughout the length of the commutator, and brass wire brushes are used to collect the current. The brush holders and rocker arm are exceptionally heavy, even for British design. The dynamo is

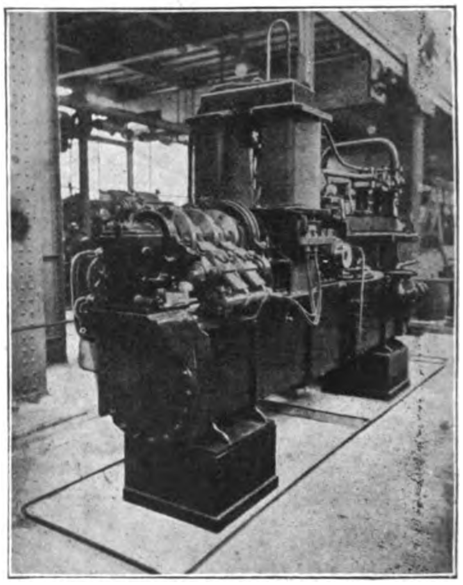
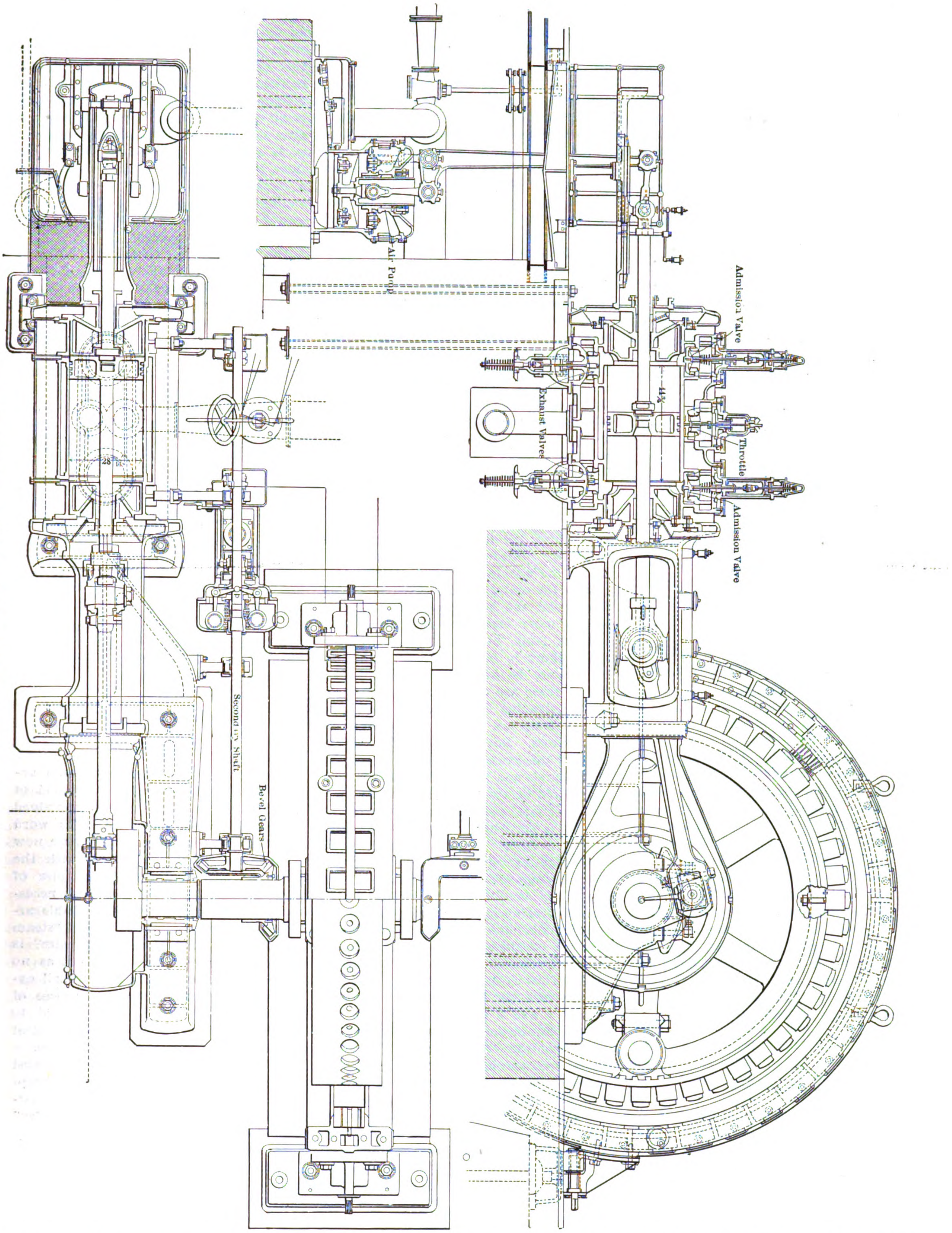


FIG. 5.—100-H P. PARSONS TURBINE.


Air Pump
Admission Valve
Exhaust Valves
Throttle
Admission Valve
Secondary Shaft
Bevel Gears
28

FIGS. 6 AND 7.—LANG CROSS-COMPOUND 1900-H.P. ENGINE DRIVING GANZ THREE-PHASE 1200-KW. ALTERNATOR.

of the inverted bipolar type, shunt wound. Regulation is obtained within very close limits by an electrically-controlled steam admission valve, whose closing is determined by the position of a lever under the influence of an electromagnet in shunt across the brushes. The dynamo is compound wound. On a recent test a load of more than 70 horse-power was thrown on and off without producing more than one volt difference in the e.m.f. at the brushes, the machine running at 130 volts. The working steam pressure for the 70-kw. turbine-generator is 110 lbs., and for the larger one 140 lbs.

The turbine driving the alternator is intended for use with a separate condenser, and is not shown in operation at the Exposition. The alternator has four poles, giving therefore a frequency of 100 cycles per second at 3000 r.p.m. A small two-pole exciter on an extension of the main shaft provides current for the field. An electric regulator is employed in which a differential solenoid is used to control the steam admission. The series coil is placed above the shunt coil and draws up a core connected to the steam regulator when the current increases. The collector rings of the alternator are mounted on a varnished wood cylinder. The e.m.f. between terminals is 2000 volts. Forced lubrication for the bearings is used, oil being pumped from a reservoir through pipes on the outside of the frame.

An application of the Parsons turbine to marine work is well shown in the case of the "Turbinia," a torpedo boat at present stationed in the Seine, just off the Army and Navy Building of the Exposition. A recent test down the river showed a speed of nearly 30 knots, but the boat will do even more under favorable conditions.

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THE COMPARATIVELY SLOW GROWTH OF ELECTRIC INCANDESCENT LAMP SERVICE.

BY W. SONNEBERG.

One evening recently I noticed several small stores in which electric incandescent lamps had been displaced by gas incandescents. After having made some inquiries, I soon found out why it was that the electric incandescent, despite its natural advantages, had fallen so far behind its competitor; the explanation is given herein. Comparison of cost per candle-power between gas and electricity cannot fail to show a manifest commercial advantage in favor of the former. The table given herewith roughly shows this. The table is based on lamps burning three hours a day for three hundred days; the market prices of both gas and electricity are used.

	Per hour.		900 hrs.
50 c.p. electric incan....	.0225		$20.25
50 c.p. gas incan.........	.005	(3 mantels)	5.70
16 c.p. electric incan....	.0075		6.75
16 c.p. plain gas.........	.006		5.40

This table assumes normal candle-power for the respective lamps. It may be objected that the gas incandescents rapidly fall off in illuminating effect, but it must be noted that the prices quoted include a renewal of the mantles after 300 hours' use, whereas the makers claim that they are good for 1000 hours; so that with such frequent replenishment the initial candle-power can be fairly well maintained.

Let us turn now to the electric service, and perceive how a slight neglect or carelessness in laying out a plant may be the means of defeating the ends for which the plant was established. In the first place, as is well known, a few per cent drop of pressure in the mains below the point for which the lamps were intended, produces a marked difference in their brilliancy. And the worst feature of this loss in pressure is that it occurs just at the time of day when artificial light should be at its best, that is, at the beginning of nightfall. That is to say, the irregular fall of pressure occurs at this time; by which is meant the variation in voltage due to a varying number of lamps being thrown in circuit at once. Again, some consumers hang on to their lamps until they actually give way, when they may have fallen off in candle-power as much as 50 per cent. Another cause of poor results, and one easily remedied, is carelessness in selecting, in the first place, the proper voltage lamps for the particular point on the circuit at which they are used. Instead of practical tests on this point it appears customary to calculate theoretically what the voltage at certain terminals ought to be, and to try to hold the pressure at that point despite the impossibility of accurate results due to leaks and joints, the adding of branches not originally intended to be added, vitally affects the working of the whole network.

Since the central station manager knows that under the best conditions the electric is more expensive to operate than the gas lamp, he should bring to bear every effort in order that the lights on his system be kept at a standard. Of course there are conditions under which, notwithstanding the greater cost, the electric lamp can hold its own against all competitors. But should central station men for this reason be satisfied to rest on their laurels and lose business which they could hold by strict attention to the simplest and most obvious rules of the trade?

What is particularly referred to as open to improvement is general store and house-lighting service, in which a few electric lamps are placed in each of a large number of small buildings scattered over a considerable area. Instances have come to my notice, due to causes already cited, where a customer is paying for a 16-c.p. light and received only 14 or 12, and sometimes as low as 10 candle-power. Actually in one case the lamps were running as low as 6 and 8 candle-power. Two adjoining stores, the one equipped with electrics, and the other with gas incandescents, form an object lesson which should convince the most obdurate of the necessity for keeping the former up to the mark.

It may be urged against the use of the gas lamps that they, in some instances, although cheaper per candle-power, give more light than is needed; that is to say, they give 50 candle-power where 16 candle-power would be sufficient. For general illuminating purposes, and it is this class I am discussing, the nearer an artificial light approaches the natural, the more satisfactory the results; hence it may be stated that the stronger the light, up to a certain point, the nearer it answers requirements. Undoubtedly, the best artificial illumination is where the light is evenly distributed; when 100 candle-power is available, the best arrangement would probably be to split this up into 10 lamps of 10 candle-power each, or 20 of 5 candle-power each. But where there would be only one lamp installed on a certain fixture anyhow, a decided advantage usually accrues from having it as strong as possible, up to a certain point, for the money expended.

The fact that the electric incandescent has natural advantages over its competitors, where the question of price is not all important, should not lead the central station manager to rest satisfied with a service poorer than the best, nor allow him to console himself for an indifferent lighting service by the thought of an increasing motor load. He, the manager, may pride himself on having no complaints, and still may be losing ground, which would be the case if for two customers gained one should drop off. Few consumers understand any of the principles governing electric lighting, and they may take it for granted that the service they receive is the best obtainable from that particular source, and hence go over to the use of gas or other illuminant without making any complaint to the central station.

Wherefore it may be safely concluded that the exercise of a little care and judgment would greatly increase the satisfaction of present customers and induce the addition of new ones.

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THE STEAM CALORIMETER.

BY A. F. NAGLE, M. E.

The name "calorimeter" has been applied to an instrument with the aid of which the amount of moisture contained in steam can be calculated. The word signifies "heat-measure," and as we now have coal calorimeters, with which the potential heat contained in samples of coal is ascertained, it has become necessary to designate the subject of this article by its more specific name of "steam calorimeter." The word "calorimeter" is not satisfactory to engineers, but as no one has suggested a name that shall express more clearly the exact purpose of the instrument, we shall be obliged to continue to use it, with a mental protest against the limitations of our language.

The term "saturated steam" is also used in a sense contrary to the general conception of the meaning of the verb "to saturate." What we mean to say is "dry" steam, but we have inherited the expression "saturated" which is intended to indicate saturation by heat. This expression is the more unfortunate because we shall some day have a table of saturated steam for different pressures and different velocities of flow. Quiescent steam, at constant temperature, is generally taken to be "dry" steam, and is conventionally called "saturated."

Steam flowing in a pipe at a given velocity is capable of carrying a certain amount of moisture, and for each pressure and velocity there must be a maximum quantity of water which can be carried by the current in the shape of a mist, or finely divided spray, the surplus of which moisture will be precipitated, like a rain, upon the sides and bottom of the steam pipe. Experiments have been made showing as much as 50 per cent of moisture, but no systematic attempt has been made to determine the maximum possible moisture which may be held in solution as mist, or spray, at the different pressures and velocities. As a matter of fact, however, these large percentages of moisture have been artificially produced for laboratory work, but have little practical application. I shall dwell for a moment on this question of the character of the steam to be tested before discussing the steam calorimeter.

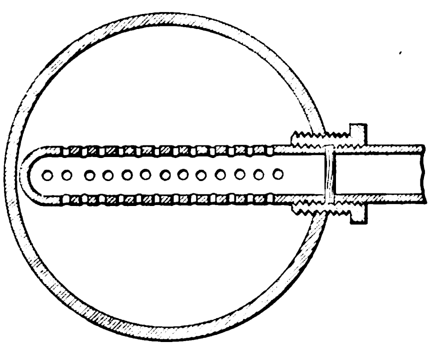
FIG. 1.—DELIVERY NOZZLE FOR TAKING SAMPLES OF STEAM.

The phenomenon of moisture in steam has always been recognized, but it has remained for the calorimeter to disclose the extreme difficulty of obtaining a fair sample of the steam to be tested. To obtain from a great mass of material fairly representative samples for scientific purposes is not an easy matter, but I venture to say that no one suspected this difficulty when steam calorimetry was first undertaken. One would think that a sample of steam could be as easily obtained as a sample of gas, but it is not. Steam in pipes loses its heat constantly by radiation or convection, thus producing condensation, and this condensed water forms along the sides and bottom of the pipes, being liable to get into the testing pipe; this makes the abstracted sample of questionable reliability.

Unless the reader has had some experience in this matter he will be surprised to learn that while the calorimeter itself is recognized to be a reliable instrument in skillful hands, no agreement exists among experts as to the manner of obtaining a fair sample of the steam to be tested. I am not now referring to small percentages of inaccuracy; the entire result may be valueless for want of a recognized and undisputed fair sample. So great are these difficulties that it is very discouraging to the practical engineer. Fortunately, however, these extreme results were obtained in laboratory tests, and if we keep within the practical limits of about 4 or 5 per cent moisture fairly reliable samples can be obtained. My own study of the problem has led me to adopt the method recommended by Mr. Barrus, and illustrated in Fig. 1, as the best of existing practice. The test pipe is generally ½-in. gas pipe, and the holes ⅛-in. in diameter. The test pipe should be inserted in a vertical steam pipe, if possible, and be placed horizontally in a horizontal steam pipe.

CALORIMETERS

About 30 years ago great efforts were being made to introduce new types of steam boilers, some claiming to evaporate as much as 16 lbs. of water per pound of coal. That the builders passed through their boilers 16 lbs. of water per pound of coal burned could not be disputed, but that all of the water was evaporated was controverted, of course. Consulting engineers were, therefore, driven to study the problem of moisture in steam in a practical way. Existing steam tables gave the amount of heat, called heat units and designated by the letters B. T. U. (British thermal units), contained in one pound of steam. Hence, by condensing some steam in a barrel of water and noting the weight and temperature of this water before and after the steam was let into it, data were obtained from which the evaporated quantity of water could be ascertained. This method of testing the quality of steam, and the apparatus devised for its application, was called the "barrel calorimeter." A more expressive name would have been "condensing" calorimeter, but the old homely name still adheres to it. The apparatus consisted of nothing but a pair of scales holding a barrel of water, a stirrer, and a delicate thermometer, as shown by Fig. 2.

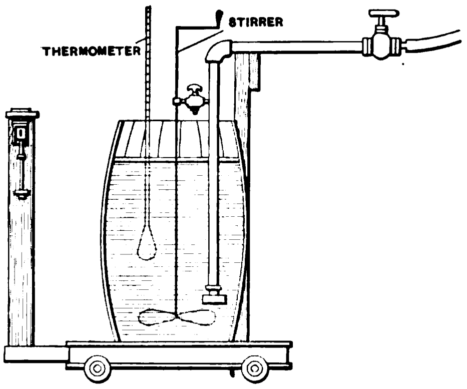

FIG. 2.—BARREL CALORIMETER.

This apparatus was first used by Mr. Hirn in 1865, and for 20 years or more we had no other. But simple as it was, it was so far from giving reliable or reasonable results that the late Mr. Geo. H. Babcock said in 1885 that "at the electrical exhibition the judges found it necessary to throw out all the tests made by calorimeters and guess at the result, for there was more agreement among the guesses than among the calorimeters." This failure was due to the extreme accuracy required of the scales and thermometers. The application of this method also demands that the wood in the barrel and the iron in the hoops and the stirrer must be reduced to their equivalent weight and specific heat in water, and this, added to the weight and heat of the water. Then, on a cold day, or any day, radiation or convection of heat from the barrel also affects the result.

In order that the reader may have a correct appreciation of the niceties of measurements and observations required, the formula used in the calculations is herewith given, and also a table worked out by Mr. Wm. Kent to show the effects of errors in any one or all of the several measurements.

$$Q = \frac{1}{H - T} \times \left[\frac{W}{w} \; t_f - t) - (T - t_f) \right]$$

In the above formula,

Q = quality of steam for dry steam Q = 1.
H = total heat of one pound of steam at observed pressure.
T = total heat of one pound of water at observed pressure.
t = total heat of original water in barrel.
t_f = total heat of final water in barrel.
W = weight of water in barrel originally.
w = weight of condensed steam.

	Incorrect reading.	True reading.	Error.
W = weight of water.....	200.5 lbs.	200 lbs.	½ lb.
w = " steam condensed	9.9 lbs.	10 lbs.	$\frac{1}{10}$ lb.
P = steam gauge pressure.	78. lbs.	80 lbs.	2 lb.
t = temperature of cold water	44.5°	45°	½°
t_f = temperature of heated water	100.5°	100°	½°

	Q.	Per cent moisture.	Per cent error.
When all readings are correct...	.9874	1.26	.0
All correct except W = 205.5 lbs.	.9906	.94	.32
" " w = 9.9 lbs.	1.00	.00	1.26
" " P = 78. lbs.	.988	1.2	.06
" " t = 44.5°....	.9989	.11	1.15
" " t_f = 100.5° ...	.9994	.06	1.20
If all readings are incorrect......	1.027	—2.72	—3.98

In other words, if all readings were incorrect to the extent given, the test would show 50° of superheating instead of 1.26 per cent moisture. We may therefore just-

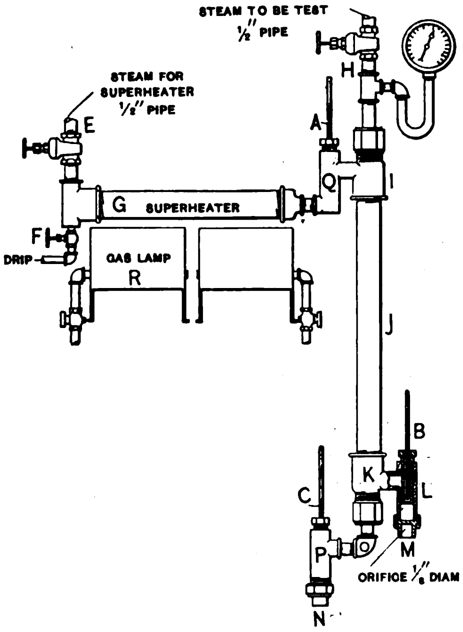

FIG. 3.—SUPERHEATING CALORIMETER.

ly conclude that the barrel calorimeter is no longer to be used, except by persons whose expert skill in determining extremely accurate measurements is unquestioned.

The next step in the evolution of the steam calorimeter was made by Geo. H. Barrus about 1885, when he first attempted to evaporate the unevaporated water in the steam by means of superheated steam generated in the apparatus. The apparatus is shown in Fig. 3. The steam to be tested passes through pipe, H, and out at the orifice, N, of known size. The pipe, H, is surrounded by a pipe, J, and superheated steam, generated as shown, fills the annular space between the two pipes and is discharged at the orifice, M, of known size. Thermometers and gauges are inserted where shown, and from the data thus obtained accurate calculations can be made of the moisture of the steam.

This instrument was a very great advance over the barrel type, and excellent work was done with it for several years by Mr. Barrus, but it was destined to be superseded in 1888 by the throttling, or wire-drawing, type devised by Prof. Cecil H. Peabody, and illustrated by Fig. 4. Prof. Peabody's device practically completed the discoveries of natural laws applicable to the operation of a successful steam calorimeter. All subsequent inventions are only intelligent applications of these laws to adapt the instrument to practical uses.

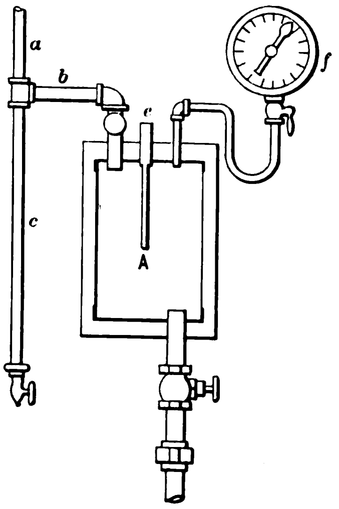

FIG. 4.—PEABODY'S THROTTLING OR WIRE-DRAWING CALORIMETER.

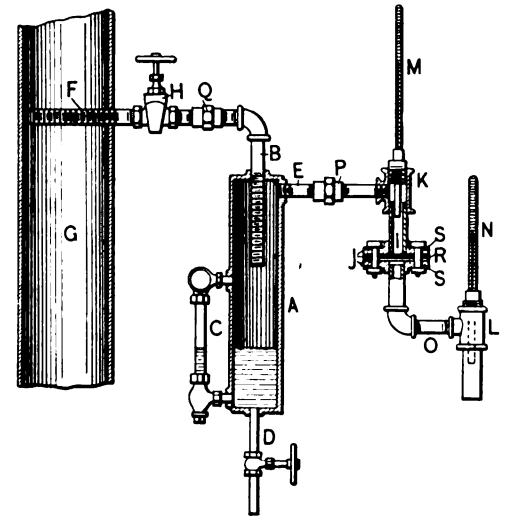

FIG. 5.—THE BARRUS COMBINED THROTTLING AND SEPARATOR CALORIMETER.

The Peabody calorimeter operates upon the principle of utilizing the superheat of wire-drawn steam to evaporate any moisture existing in the steam. This instrument is simplicity itself, and in fairly skilful hands, with ordinarily good thermometers, reliable results are obtained. It has, however, its limitations of range of moisture; it will detect, say, from 4 per cent to 5 per cent. Prof. Peabody gives the following formula for calculating the quality of the steam:

$$X\,r + q = H_1 + .4805\ (t_s - t_1)$$

Here,

X = quality of steam; dry steam = 1;
$1 - X$ = moisture;
r = heat of vaporization of the steam to be tested;
q = heat of the liquid corresponding to r;
H_1 = total heat of steam in the calorimeter.
t_1 = temperature corresponding to H_1;
t_s = temperature of the superheated steam in calorimeter.
0.4805 is the specific heat of steam at constant pressure.

To solve for X, the formula may be transposed to read

$$X = \frac{H_1 - q + .4805)\,t_s - t_1)}{r}$$

To illustrate this formula, suppose the boiler gauge pressure is 150 lbs., the pressure in the calorimeter is 3.3 lbs. per square inch, and the temperature of the superheated steam is 260°. Then a steam table gives the values: $r = 860.6$; $q = 358.2$; $H_1 = 1149.8$, and $t_1 = 222.4$; and the thermometer gives $t_s = 260$. Then,

$$X = \frac{1149.8 - 358.2 + .4805(260 - 222.4)}{860.6}$$

$= .94$, and the moisture is $1 - .94 = .06$, or 6 per cent.

In 1890 Mr. Barrus brought out his universal steam calorimeter shown in Fig. 5. This instrument combines the principles of precipitation of excessive moisture in a separator and of the evaporation of the remaining portion in the wire-drawing construction. It is a fact that steam containing 6 per cent or more moisture will deposit all of this moisture in a separating chamber except about ¼ of 1 per cent. Prof. Carpenter has constructed calorimeters embodying only this separating feature. The small quantity remaining can be determined by the throttling, or superheating, principle.

It is not my purpose to go into the constructive features of the several steam calorimeters on the market, but I have endeavored to explain the principles upon which those now in common use are designed, and what has led up to their present state of perfection.

ELECTRIC ELEVATOR CONTROL.

BY HAYWARD COCHRANE.

The usual requirements of an electric elevator controller may be stated briefly. That the full speed of car shall be attained in from five to eight seconds' time, depending on load and rated speed of elevator. That in attained speed the acceleration shall be smooth and gradual, so that no jerk or jump will be felt on the car. That the rush of current in starting the car shall be as small as possible consistent with the rate of acceleration, and its rise from initial rush to maximum value be steady and gradual so as to cause little drop of voltage, and thus allow the machine to be run on incandescent lighting circuits. That the controller be so constructed as to operate easily with either cable or lever device. That the speed be variable from minimum to maximum at the will of the operator, and that the design of contacts and connections be such as to obtain a minimum of sparking, with a long life of said contacts.

The earlier electric elevator machines were operated by a plain shunt motor, the controller being such as simply to vary a resistance in the armature circuit, while the starting switch was a simple double-throw reversing switch for making and breaking the connections to field and armature. With a simple shunt motor, however, the rush of current taken to start an elevator under full load is often double or more of the amount taken to run it at full speed, while the influex comes so suddenly that the drop in pressure is excessive. To rush this high rush current, and at the same time get the large torque needed for rapid acceleration of car speed, motors having a compound winding have been adopted. The first method of using the compound winding was to keep it always in circuit while running, and use the same design of controller as with the plain shunt motor.

By having the series winding operate in unison with the shunt winding a powerful field was obtained in starting the load, thus requiring a much smaller proportion of current in the armature. With a larger amount of series winding a proportionally smaller starting current could be obtained, but with a very large proportion of series winding with the special design of motor and mechanism used, it was found that the running efficiency of the machine was lower considerably than that obtained with a simple shunt-motor outfit. It is not the intention here to convey the idea, however, that a compound motor could not be designed to give as high an efficiency as a shunt motor of the same rated power, provided that alone was the result to be attained.

With a series winding made up in sections and connected to a commutating device in the controller it was possible to use a large proportion of series winding in starting the load, and then cut it out of circuit section by section and finally run at full speed using the shunt winding only.

Some designers have gone as far as to use an abnormally large motor frame excited by a series winding of sufficient magnetizing power and ohmic resistance to allow the motor to be started up without any external resistance in the armature circuit. The series winding was arranged in sections so as to be cut out of circuit step by step and finally cause the motor to run at full speed as a shunt motor. By this means a very small starting current was obtained, together with a fairly good full speed running efficiency with shunt coils only. By using the motor compounded in this manner in starting and excited by the shunt field alone in running, very good results have been obtained on slow speed elevators where a gearing of high ratio and low efficiency was employed.

One of the first things to be attained in elevator service is safety of operation, which should not be sacrificed for any other object. If a compound motor is used with a gearing of low ratio and high efficiency, there may be times when the motor will be driven by its load sufficiently to generate quite a large current. If the series winding of the motor in such a case happens to be cut out of circuit the armature will simply have to generate its e.m.f. in the strength of field given by the shunt winding, and a runaway may result. If the series winding happens to be partly or wholly in circuit while the load drives the armature, there may be a balanced condition so that no effective current will flow in the series coil in either direction, or the current in the series winding may be reversed in direction and will in such a case act to weaken the field given by the shunt winding, and the result in this case is also likely to be a runaway. It is, therefore, desirable to have the controller so designed that it will automatically prevent this weakening of the field irrespective of the running position of the operating device whenever the load may drive the motor. It is also desirable to be able to slow up the speed of the car when descending with a heavy load, or to run at varying speeds at will, no matter what the size of the load is.

By means of some automatic commutating device, such as is represented in Fig. 1, working in connection with a compound-wound elevator motor controller, these advantages may be obtained. The series field winding will work cumulatively in starting the motor so as to give a relatively large torque with a minimum rush of current. It may be partly or wholly removed from circuit at the will of the operator so as to give varying car speeds. In cases where the load is of such an amount as to cause no flow of current in the series circuit after reaching full speed the series winding may be kept out of action. If the load is such as to drive the motor and generate a current in the series circuit, the connections of the series windings may be reversed so that this current, which would otherwise tend to neutralize the effect of the shunt field windings, may act accumulatively with the shunt windings to strengthen the field. This causes the load to drive the armature at a slower speed than it would have if the shunt windings alone were in action. The heavier the load, therefore, the larger the reverse current in series coils, the stronger the field and the slower the speed of the elevator. As soon as the operating device is brought to the central or "off" position, the normal starting conditions will automatically be resumed.

In Fig. 1, A is the movable contact brush of a starting rheostat which short-circuits, step by step, a resistance in series with the motor armature; B is a similar contact brush mounted on the same frame with the brush, A, but electrically insulated from it. The contact brush, B, short-circuits, step by step, sections of the series winding on the motor field magnet; this short-circuiting beginning after all of the armature rheostat has been cut out by the brush, A. The terminal contacts of the series field are electrically connected with contact brushes, C, D, E and F, which are arranged to slide on contact plates, G, H, and I, mounted on an insulating block, J, which is adapted to be moved up or down by the solenoid coil, K, when attracted upward by the solenoid, L. The diagram shows the coil, K, and its sliding switch in the position at starting. The controller switch, the movable contacts of which are marked M and the stationary contacts N, is a simple reversing switch, as an inspection of the circuits will show, its function being simply to connect the motor in circuit, the direction of current flow through the armature being determined by the direction in which the switch is thrown.

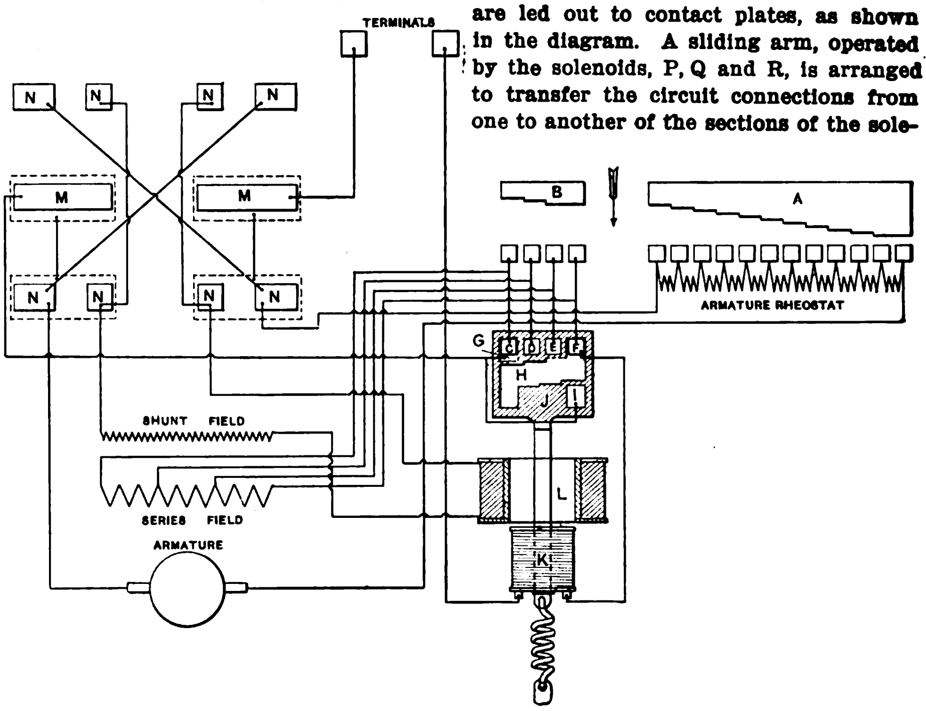

FIG. 1.—AUTOMATIC ARRANGEMENT TO PREVENT RACING.

When the motor is running as a motor and the current is flowing through the armature in the normal direction, the coils, L and K, repel each other, so that the sliding switch remains as shown in the engraving. This state of affairs continues up to the point when the motor is driven as a dynamo by the load, in which event the current is reversed through the coil, K, and it is attracted upward, the operation of the sliding switch being such as to cut out, one by one, the series coils on the motor field magnet. If the current generated by the motor continues to be greater than desirable after the series coils are cut out, the coil, K, continues to be attracted upward by the coil, L, and the sliding switch cuts the series winding into circuit again, but in the reverse direction, so that it strengthens the field of the motor and reduces its speed. It is obvious that any degree of control within reasonable limits is obtainable by the adjustment of the tension of the retractile spring which opposes the motion of the coil, K.

Fig. 2 represents diagrammatically a system of electrical control for use in connection with the arrangement shown by Fig. 1. The controller spindle, S, on which is mounted the switches, A, B, and M, in Fig. 1, is operated by two solenoids wound in sections, the terminals of which are led out to contact plates, as shown in the diagram. A sliding arm, operated by the solenoids, P, Q and R, is arranged to transfer the circuit connections from one to another of the sections of the solenoids, according to its position. The diagram clearly shows the various connections and it is evident that the position of the sliding cross-head controlled by the three solenoids is determined by the position of the handle, T, of the operator's switch, which is located in the elevator car. The cores of the three solenoids are indicated by the solid black parts of the sketch, the clear strips being non-magnetic material. The solid black portions of the operator's switch, T, are insulating material. The brake magnet is arranged to withdraw the pressure of the brake, which is normally applied by the usual mechanical means.

A somewhat novel and interesting type of electric elevator mechanism is outlined in Fig. 3, where M1 and M2 represent sheaves of equal diameter keyed upon the shafts of two independent motors of equal normal speeds, and I is an idler wheel to prevent the cables from chafing upon themselves when either weight, W1 or W2, is at the top of the elevator shaft. The weight, W1, is simply a guide block for carrying the sheave below it and one end of the auxiliary cables. Within the weight, W2, is a take-up block, X, to which are fastened the ends of the auxiliary cables, which pass freely through the top of W. Coil springs are interposed between X and the top of W to maintain as nearly as possible a constant tension upon the auxiliary and the motor cables. The brake, B, is held out of action magnetically at all times except when the motors, M1 and M2, are cut out of circuit. The weight, W2, may be made as heavy as desired up to an amount equal to the weight of the car plus half the load to be lifted, so that this type of machine allows the car to be over-balanced as much as a winding drum outfit.

While in continuous service both motors are kept running, but are stopped entirely if the elevator is out of service for any appreciable length of time. The action of the two motors is differential. If the motor, M2, runs faster than the motor, M1, it will draw the weight, W2, downward, which, of course, draws the weight, W1, and the car upward. If, on the other hand, the motor, M1, runs faster than the motor, M2, the reverse action takes place and the car is allowed to descend. To stop the car, therefore, the two motors have to be brought to the same speed.

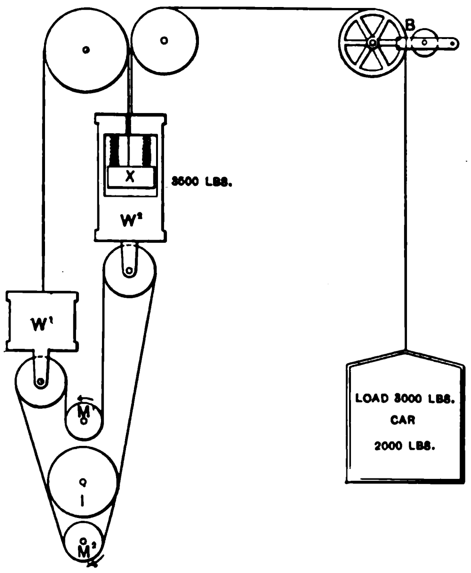

FIG 3.—DIFFERENTIAL WINDING PLAN.

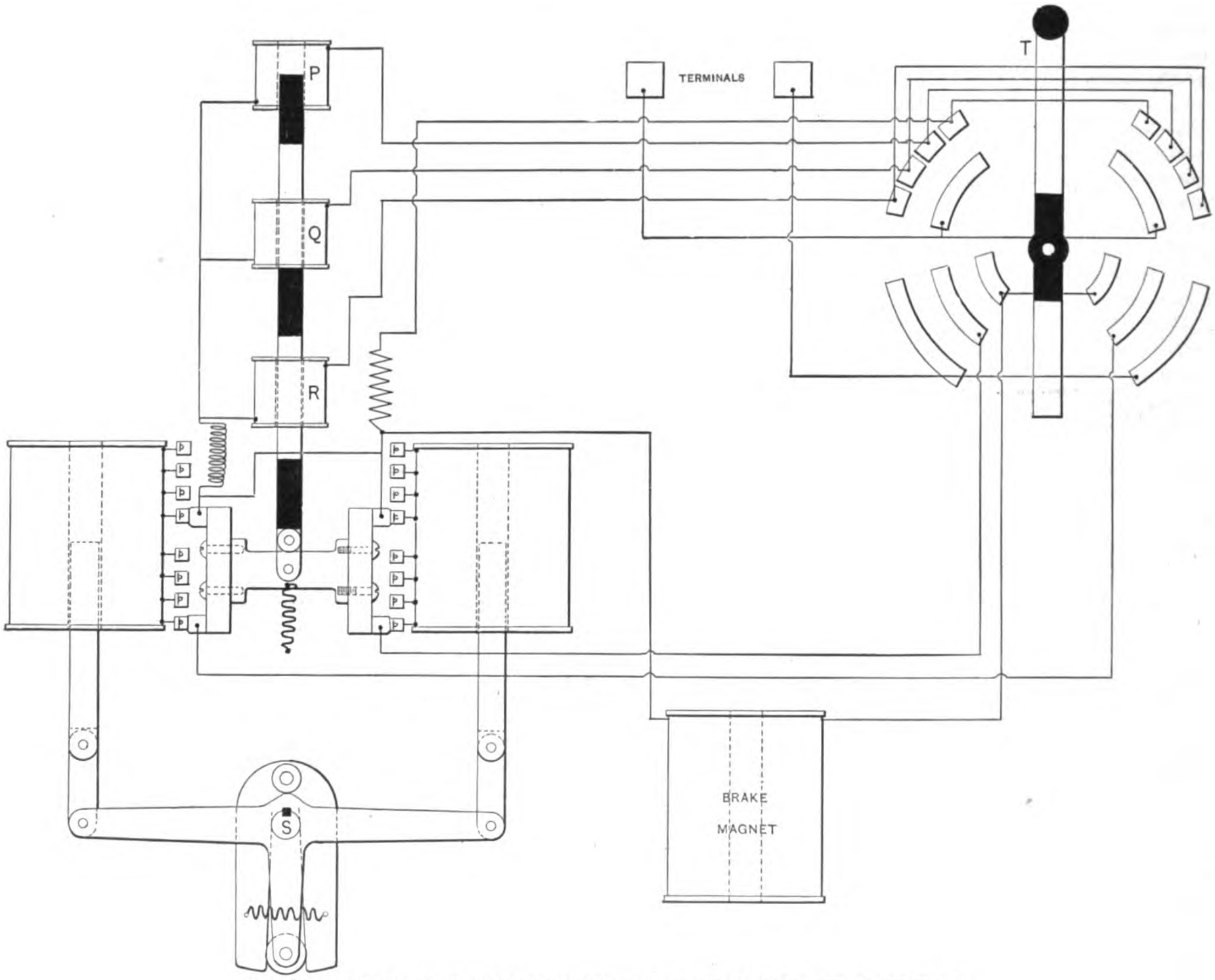

FIG. 2.—DIAGRAM OF ELECTRICAL CONTROLLER FOR SYSTEM SHOWN BY FIG. 1.

As to the actual work done in moving the loads, therefore, this type of elevator mechanism is as economical as the winding drum type. It has the advantage also of easy electrical control, smoothness of operation and accurate speed regulation.

Some of its objectionable features may be mentioned. One of these machines which is in practical operation has motor sheaves about 16 ins. in diameter, while the endless cables are of about ⅝-in. rope, with a 5/16-in. steel cable as a core. Six such cables are used for a machine of the above-named capacity. The difficulty of splicing six cables so as to make them exactly of the same length is apparent, and if they are not of equal length the shorter cables have to stand a greater strain and give out sooner. In actual practice they do not last over two or three months and it is found difficult to make splices that will be serviceable and safe. Moreover, the bending of ropes or cables round sheaves of small diameter wears them out rapidly. If the motor sheave, M2, revolves at 200 r.p.m. at its slowest speed, it will pay out cables at the rate of 836.42 ft. per minute. If the car is to have a speed of 400 ft. per minute the endless cables must be drawn in by the motor sheave, M1, at the rate of 1636.42 ft. per minute, or 800 ft. faster than the sheave, M2, pays them out. This means that the motor sheave M1 must run at a speed of 391 r.p.m. It is plain, therefore, that very slow running motors must be used or the sheaves M1 and M2 must be of exceedingly small diameter.

Furthermore, the elevator mechanism

referred to here has two 30-h.p. motors, while a winding-drum outfit to give same capacity requires one motor of about 27½ horse-power with a normal speed of about 800 r.p.m. The cost of motors, therefore, for the above type of machine is double that of a winding-drum outfit, or more. Except when the car is shut down for a length of time the electric brake, B, is taking current; in other words, it is not released and applied each time the car starts and stops. The size of this brake solenoid is greater than that generally used for a brake that is released and applied for each start and stop of the car, one reason being that the current is kept on the solenoid nearly continuously instead of intermittently, as with the ordinary brake. Moreover, a considerable amount of energy is wasted in keeping the large motors running at even a slow rate of speed while the car is not moving.

The general economy of operation of a winding-drum machine, especially if equipped with a mechanically released brake, is far greater than that which can be obtained from either a multiple-traveling-sheave machine or a double-motor continuously-running-cable mechanism.

A method of operating an elevator which has been figured out but not tried practically, so far as known, is to have the motor direct coupled to the drum shaft. This method, if it could be used, would doubtless give the highest efficiency obtainable from any form of elevator mechanism. Assuming a load of 3000 lbs. and a speed of 400 ft. per minute, as above, it would be necessary to use at least two ⅞-in. steel cables. As it is not best to run such cables over a drum of less diameter than 40 times the diameter of the cable, this would require a drum of about 36 in. diameter. For a building 224 ft. high, a drum at least 28 ins. long would be needed. To give a car a speed of 400 ft. per minute the drum and motor would have to revolve at the rate of 41.6 r.p.m. This would require a motor of abnormal design and low efficiency, but the total machine efficiency might nevertheless be high. One of the principal objections to such an arrangement would be the difficulty of operating the brake positively and safely, and there might be a lack of flexibility also in the general operation. It would be necessary to have an electrically-released brake in connection with the overhead car supporting sheave which could be applied at any time when desired, or which would automatically apply in case of current failure.

The foregoing is an abstract of a paper read before a recent meeting of the Chicago Electrical Association.

Abstracts from Foreign Contemporaries

Return Currents of Railways.—In a recent issue of the London "Electrician" reference is made to the double overhead trolley system which is used in Cincinnati and Washington and is claimed to remove all danger of electrolysis from return currents. This system, naturally, does not meet with the approval of the writer in the "Electrician"; he relegates it to the "limbo of curious failures," and suggests instead that the ordinary trolley system be provided with an underground insulated return connected permanently to a series of surface-contact studs along the track-way. While the principal drawback of surface-contact systems is the complicated mechanism required for connecting and disconnecting the contact studs at the proper moments, this difficulty is not present when all the studs are on the return conductor and are never at more than, say, 7 volts above the potential of the earth.

Induction Motors with Fly-wheels.—In a paper by O. Lasche in a recent issue of the "Technisches Centralblatt," and the London "Electrician," the use of induction motors in iron works and rolling mills is discussed at some length. The main point of the discussion is the combination of an induction motor and a flywheel for use on intermittent work. As the speed of the motor diminishes somewhat when the load increases, the momentum of the flywheel can supply momentarily a part of the requisite power, so that the motor may be considerably smaller than the maximum power would require. There are two main periods in the cycle of operation; the period of work when the motor as well as the flywheel give out energy, and the period of recovery when the motor stores up energy in the flywheel to be used in the next period of work. He discusses several cases. When motors of different sizes, but all of equal percentage slip, are available, and the period of load has a certain fixed duration, then the longer the period of recovery (that is, the longer the pauses between two periods of work), the smaller may be the size of the motor; of course, a correspondingly heavier weight of flywheel has then to be used. This can be seen in the diagram, Fig. 1, where three motors of different sizes are compared; the three upper curves give the variation of speed, the three lower curves the peripheral force developed by the motor, so that from the form of these curves the relation between the energy given from the motor and given from or to the flywheel can be found; the maximum powers of motors I, II, III, is 170, 320 and 470 horse-power, respectively, while the corresponding flywheel masses are 690, 530, 318; the period of load is in all three cases five seconds, while the periods of recovery are 33, 15.75 and 7.15 seconds, respectively. If all the motors are of equal sizes and have equal slips, the longer the periods of load the heavier must be the flywheels and the longer must be the period of recovery. If all the motors are of equal sizes, but have different slips, and the period of load has a certain fixed duration, then the smaller the slip, the heavier must be the flywheel.

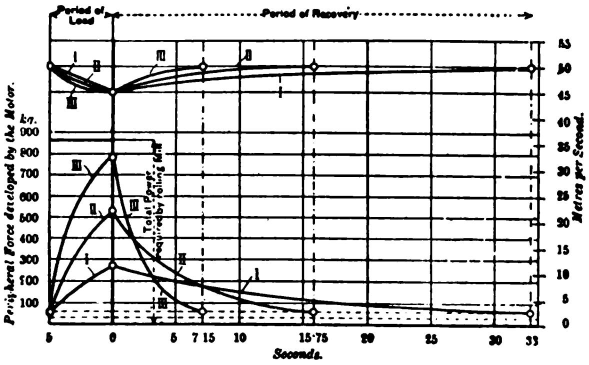

FIG. 1.—CENTRIFUGAL FORCE CHART.

Automatic Circuit-Breaker.—A new automatic circuit-breaker made by Schuckert & Co. is described by Mr. H. Mueller in a recent issue of the "Elektrotechnische Zeitschrift." It is shown in Fig. 2. The current enters at *p*, flows through the coil, *s*, and the two branches, *c*, and *a*, *d*, *b*, connected in parallel, and leaves the circuit breaker at *n*. The circuit is interrupted by the upward movement of the tubes, *m* and *t*, by which the pieces, *c* and *d*, are removed from the position indicated by straight lines to the position indicated by dotted lines.

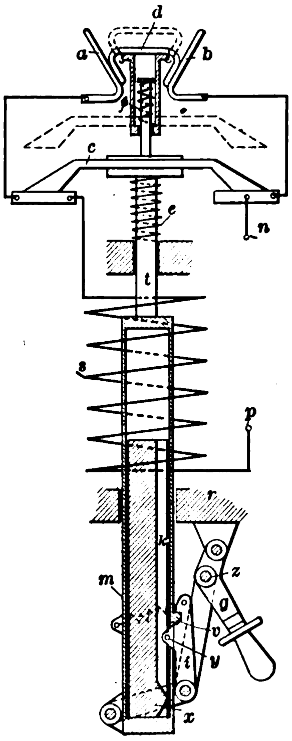

FIG. 2.—CIRCUIT-BREAKER.

The coil springs, *e*, tends to lift the tubes, *m*, *t*, upward, but normally they are kept down by means of the lug, *v*, which is arrested by the hook of the latch, *i*; to interrupt the circuit the latch must therefore be thrown outward. This may either be done by hand with the aid of the lever, *g*, or it occurs automatically when a current above a certain limit flows through the coils, *s*. The tube, *m*, contains loosely an iron core, *k*, which when attracted upward pushes outward the nose, *y*, of the lever, *i*, by means of the nose, *x*. To reset the circuit-breaker after it has worked automatically, the lever, *g*, has to be raised so that the hook of the latch, *i*, catches upon the lug, *v*; then the lever, *g*, is brought back into the position shown in the figure. Should the current at this moment still be above the allowed limit, the automatic device works immediately and interrupts the circuit again.

Poulsen Telegraphone.—In a recent number of "L'Eclairage Electrique" Prof. J. Blondin describes some very interesting special applications of Poulsen's telegraphone, the general arrangement of which was described in these notes in the September issue. Fig. 3 shows its use as a telephonic relay and a device for multiplying telephone messages; here, *T* is a drum around which a steel band is wound, and which rotates at high speed. *A* is an electromagnet connected to the microphone, *M*; from this magnet the steel band receives the magnetic record of the spoken words; these sounds are then reproduced in the telephones, *t*, *t'*, *t''*, etc., connected to the electromagnets, *a*, *b*, *c*, etc. The electromagnet *B*, which is excited with direct current, destroys the record, so that each point of the steel band after it has passed *B* is prepared for a new record from *A*.

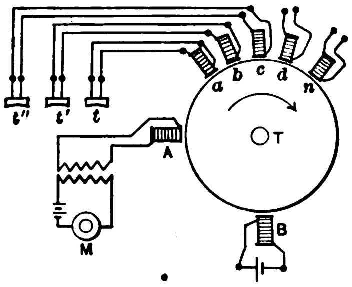

FIG. 3.—TELEGRAPHONE.

Another application is for duplex telephony; the scheme is based upon a principle by which it is possible to record two different messages on the same steel band and to have the messages reproduced separately. This is accomplished by the use of two electromagnets; one message is recorded while the two electromagnets are simply connected in series and the second message is recorded while the connections of the electromagnets are reversed. For reproducing the one or the other message, the connections of one of the two electromagnets which are to be used with the telephone receiver are to be reversed. How this principle is applied for duplex telephony may be seen from Fig. 4. Here *S* and *S*1 are two drums which revolve with equal speed and around which steel bands are wound; *A* and *B* are two groups of two electromagnets each; the connections of the two magnets, *A*, differ from those of the two magnets, *B*, in that the connection of one is reversed in the group, *B*, as compared with the group, *A*. When *A* is connected with a telephone transmitter and *B* with a receiver, no sound would be heard in the receiver although the steel band is prepared with a magnetic record by *A*. At the other station, shown at the right hand, the groups *A*1 and *B*1 are arranged in the same manner. The currents are transmitted from the electromagnet, *C*, over the line to the electromagnet *C*1. *D* and *D*1 are electromagnets supplied with direct current for destroying the record. In this way two messages may be transmitted from *A* and *B* at the same time over the same line; the message from *A* is received at *A*1 and that from *B* at *B*1.

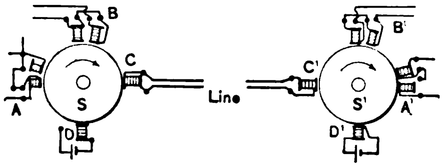

FIG. 4.—TELEGRAPHONE.

Ferranti Arc Light System.—A recent issue of "Lightning" contains an interesting description of the Ferranti arc-light system, which has found a rather extended application in Great Britain, as it enables station engineers to combine practically all the advantages of direct-current supply to arc lamps with those of alternating-current transmission without any multiplication of generator types in the station. Mr. Ferranti accomplishes this with his rectifier, which converts variable alternating current, supplied by the generators at a constant potential voltage, into uni-directional constant current at variable voltage. The apparatus consists essentially of three parts; a constant-current transformer, a synchronous motor, and a high-tension commutator, driven at synchronous speed by the motor; Fig. 5 illustrates the complete apparatus. The constant-current transformer is identical in principle with the well-known General Electric apparatus. The primary coils, *A*, are stationary, while the secondary coils, *B*, are mounted on a carriage and are free to move outward from the primary coils when the magnetic repulsion is sufficient to lift the adjustable counterpoise, *E*. A quadruple water-break switch, *F*, is attached to the frame of the constant-current transformer and connects the secondary coils with the high-tension rectifying commutator, *M*, driven by the synchronous motor, *H*.

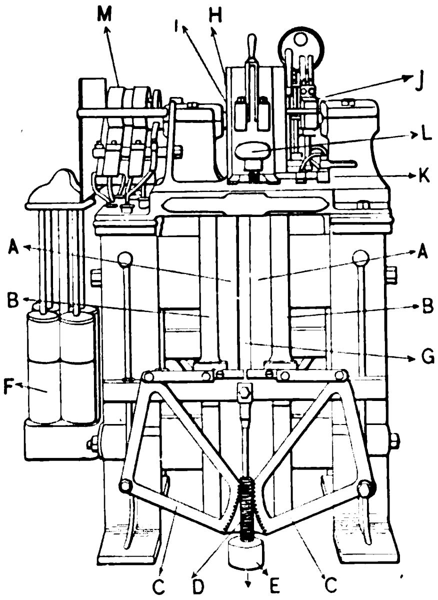

FIG. 5.—FERRANTI RECTIFIER.

Alternating Current Arc Lamp.—In a recent meeting of the International Society of Electricians in Paris, Mr. De Lenart read a paper on a new alternating current arc lamp of Ganz & Co., of Budapest, which is reprinted in the "Bulletin" of that society. Nearly the whole light emitted by this lamp is said to be distributed within the lower hemisphere. The principal feature is that the carbons are not vertical, but inclined, each forming an angle of 45° with the axis of symmetry of the lamp, so that one carbon is perpendicular to the other. A simple mechanism is used for keeping the distance between the ends of the carbons constant. A reflector is used above the carbons.

Wireless Telephony.—In the British periodicals a paper is reprinted which Sir William Preece read before the recent meeting of the British Association for the Advancement of Science, on wireless telephony. He describes a series of experiments which he has made on several points and says that wireless telephony across the sea is now a practical and commercial system. His system is extremely simple; no special apparatus seems to be necessary, and the ordinary telephone transmitters and receivers are used. The principal point is that for telephoning across a channel he places two lengths of wire parallel to one another on each side of the channel and earths them at both ends by earth plates in the sea itself. The connections of the apparatus are shown in Fig. 6, where *L* represents such a wire, earthed at both ends, *R* a telephone receiver, *T* a transmitter and *K* a key; the key is held in the position shown in the figure for transmitting a message; for receiving a message, the key is pressed down. The results obtained with this system seem to be due to a combination of conductive and inductive effects.

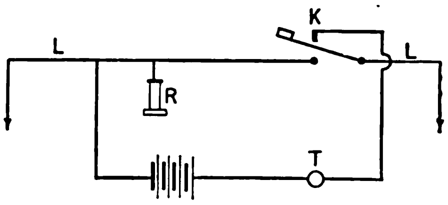

FIG. 6.—WIRELESS TELEPHONY.

Braun System of Wireless Telegraphy.—There have been given in the German contemporaries several brief references to experiments made with a system of wireless telegraphy devised by Prof.

Braun of the University of Strasburg. In recent numbers of the "Schweizerische Blaetter fuer Elektrotechnik," some information on this system is given, taken from the patent specifications. There are two patents; in the first he suggests the use of electric oscillations produced by means of Leyden jars, and induction coils; these oscillations have a lower frequency than the Hertzian waves used by Marconi. The second patent relates to the transmission of the waves along the surface of the earth; the transmitter is an apparatus generating electric oscillations and connected to two earth plates, while at the receiving end there are also two earth plates connected to the receiver with a coherer and local battery.

Heating of Underground Cables.—In a recent issue of the "Elektrotechnische Zeitschrift," Dr. R. Apt calls attention to the importance of a systematical investigation of the safe carrying capacity of underground cables, especially for cable lines of shorter length. He shows that the conditions are quite different from those of a conductor in air. While the latter may be regarded as a cylinder in an infinite medium, an underground cable behaves like a cylinder surrounded by a concentric zone of earth of certain thickness; that is the zone over which the heating effect of the cable extends in the earth. Upon these considerations he bases a theoretical treatment of both cases; for a conductor in air he obtains the well-known formula which has been proved as correct by the extended researches of Dr. A. E. Kennelly; for an underground cable he develops a different but rather simple formula. He has made a series of experiments the results of which can be well represented by the latter formula. The curves in Fig. 7 have been calculated by him from this formula; the ordinates give the safety limit of current density in amperes per square millimeter, and the abscissas the conducting copper cross-section in square millimeters. The original temperature of the cable is assumed at 15° C. For the curve, $J = 40\sqrt{Q}$, the safety limit of temperature is assumed at 40° C.; for the curve, $J = 25\sqrt{Q}$, at 25°. The third curve, V D E, is calculated from Kennelly's formula for conductors in air, for comparison, the safety temperature limit being assumed at 25° C. He remarks that his experiments may be regarded as preliminary, so that his results are not yet so well founded experimentally as Kennelly's formula for air conductors.

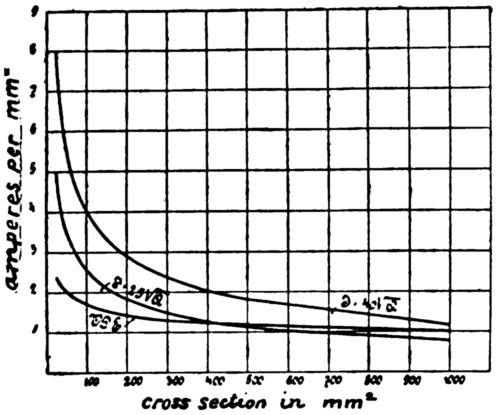

FIG. 7.—TEMPERATURE CURVES.

Electrolytic Zinc Production with By-Products at the Anode.—There were formerly great difficulties in electrolytic zinc processes; the great drawback was that often spongy zinc was obtained instead of the solid, bright metal. In a paper in recent issues of the "Zeitschrift fuer Elektrochemie," Mr. Rontschewsky gives an account of laboratory experiments in which he has endeavored to increase the economy of the process of producing zinc from solutions of zinc salts with insoluble anodes by obtaining valuable by-products at the anode. He used a solution of zinc sulphate, to which some sulphuric acid was added, and a lead anode. To obtain a by-product at the anode, he added chlorate of sodium to the electrolyte. By adding a small percentage only he produced peroxide of lead at the anode which was free of lead sulphate; by adding a great percentage of the chlorate of sodium with sodium chromate he produced chromate of lead at the anode, which, although not chemically pure, had a beautiful color and seemed to be well adapted for use as paint; in the latter case he used a diaphragm in the cell. The zinc obtained at the cathode was in both cases solid and bright and entirely free from lead.

Vulcan Meter.—In a recent issue of the "Elektrotechnische Anzeiger" Mr. R. Hopfelt describes the Vulcan meter, made by a French company and shown at the Paris Exposition. It is illustrated in Fig. 8, which shows that this meter is constructed in general like an ordinary motor meter. The principal difference being the arrangement of the braking magnets. The usual copper ring revolves between the pole pieces of 12 small U-magnets arranged in a circle and supported by a brass star. This brass star has a screw for raising or lowering the magnets and thus increasing or diminishing the damping force.

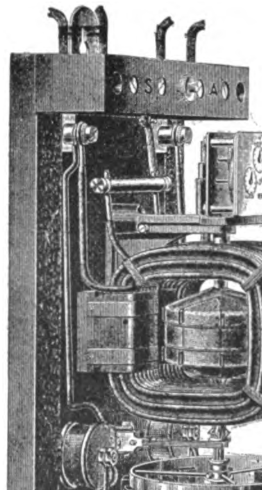

FIG. 8 —VULCAN METER.

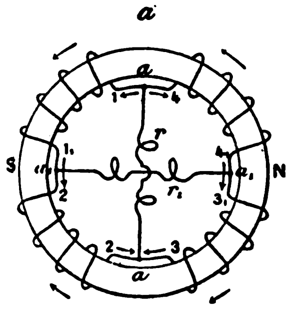

FIG. 9.—TWO POLES.

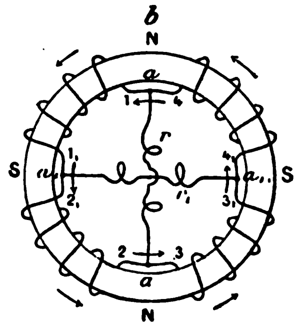

FIG. 10.—FOUR POLES.

Deri Motor.—In a recent issue of "L'Industrie Electrique" Mr. Max Deri describes an induction motor designed by him and shown at the Paris Exposition. The main interest lies in the special starting device; use is made of the well-known effect of resistances inserted in the armature circuit for starting and switched out when the motor has come up to speed. In the Deri motor the starting resistances are not really switched out, but their arrangement is such that although the connections with the armature are always the same, yet they are supplied with current only at starting, and carry no current when the motor has run up to speed. This is accomplished by changing the number of poles. The principle is illustrated in Figs. 9 and 10, in which the starting resistances are marked r and r_1; when connected for two poles, as in Fig. 9, current flows through r, and with four poles, as in Fig. 10, no current flows through either r or r_1. The motor is started with two poles and when it has run up to speed, it is changed over to four poles, by means of the switch shown in Fig. 11. The position of the switch indicated by full lines gives four poles; the position indicated by dotted lines gives two poles;

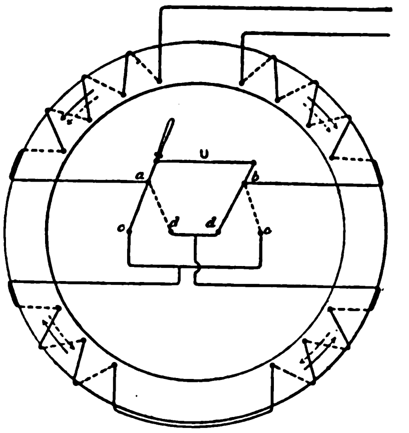

FIG. 11.—SWITCH FOR VARYING NUMBER OF POLES.

the link, *U*, is of insulating material. This method is, of course, open to the objection that the variation of the number of poles is not such as to give highest efficiency; the logical variation would be to reduce the number of poles as the motor attained speed.

Electrolysis by Railway Return Currents.—In several French contemporaries a long paper by G. Claude is reprinted, in which he describes experiments made by him during the last two years on lines installed by the French Thomson-Houston Company. Some of his conclusions vary greatly from those of other investigators. It is generally considered that the return currents can become detrimental to gas and water pipes only at those points where they pass over from the pipes into the earth, under the supposition that the earth conducts the current as an electrolyte. He has found that this is not exactly the case; the earth behaves more like a metallic conductor shunted by an electrolyte. Furthermore, while the ratio of the stray currents to the total return currents is higher than is generally supposed, being not below 12 or 15 per cent in lines with good rail joints, and amounting to 25 or 30 per cent in lines where the joints are not carefully made, yet he found that by far the greatest part of these stray currents travels simply through the earth and only a very small part goes through the water and gas pipes.

The report, recently submitted to the Union of German Electrical Engineers by the committee appointed to investigate the question of electrolysis, is also interesting, as it states that in 90 German cities with electric tramways, in only two or three cases was electrolytic corrosion of gas or water pipes observed.

Dolter Surface Contact System.—Recent issues of French contemporaries contain descriptions of the Dolter surface contact system which is used on an experimental line in Paris and for which several advantages are claimed over the Diatto system in use on several French lines. The contact blocks are placed midway between the two rails and are on a level with the road and are firmly fixed by means of cross-beams connected with the rails. At the top of the surface contact block there are two half-discs of steel embedded in ambroine. To the right hand half is pivoted a bell-crank lever, the horizontal arm of which is an iron rod, and the vertical arm a hollow ambroine tube which carries at its lower end a carbon disc. This carbon disc and the horizontal iron rod above are connected together by a fuse wire of aluminum in the interior of the ambroine tube. The horizontal arm is also connected by two flexible wires with the two halves of the contact block. When the horizontal arm is drawn upward the vertical ambroine tube swings the carbon disc at its lower end against another carbon disc which is mounted on a spring and is in connection with the supply feeder. Below the car there are two shoes or skates, consisting of two iron rods which form the pole-pieces of a large electromagnet, the two skates having opposite polarity, of course. The current passes from one skate to the exciting coils of the electromagnet and thence to the car circuit and back out at the other skate. A small storge battery in shunt with the electromagnet supplies the exciting current at starting and in case the connection should be broken. A special safety device is provided to prevent danger, should a contact block remain alive after the skates have passed it. There is a sliding contact at the end of the car which connects the rails with the contact block over which the skates have just passed, so that if the contact block remain alive the aluminum wire in the ambroine tube is fused and the contact block disconnected from the supply feeder. If the mechanism has worked normally and the contact block is already dead, this device of course produces no effect.

The Rating of Incandescent Lamps.

To the Editor, American Electrician;

Sir:—I have gone over your editorial comments upon my paper on "Mistakes in the Rating of Incandescent Lamps" printed in your last issue, with a great deal of interest. If it were obvious to everyone that incandescent lamps should be rated by the candle-power measured "end on," I suppose they would be rated in that way now. If lamp users knew how little light comes out of the end of incandescent lamps with certain forms of filament, but one form would be in common use; the one which gives most in the right direction. The proposition I made to measure lamps "end on" instead of measuring the mean horizontal candle-power is certain a radical one; but it was made after very carefully going over all the points which bear upon such a matter. I suppose some discussion is admissible, and I am glad you took issue with some of my statements, since I can now clear up more thoroughly some matters which the original paper did not consider exhaustively.

I based my statement as to the proportion of all incandescent lamps which are installed base upward or tipped end down on the results of careful observation by myself and friends for months past here in Philadelphia. I have been watching to see what proportion of all incandescent lamps are installed with axis exactly perpendicular and tipped end down every day and everywhere long enough to very confidently assert that from 85 to 95 per cent of all lamps are so placed. The very lowest estimate I have heard made (and this was by a man who chose to disagree with some of my ideas on candle-power) was that 75 per cent of all lamps installed were placed in exactly the position my paper demands they should be if all I say holds true. You see, Mr. Editor, in considering this subject one must not think too much of the electric lighting arrangements in a New York office building or in a suite of editorial rooms. Handsome electroliers rarely or never have the lamps on them installed with axes vertical; the artistic features are brought too much into prominence for that.

Remember all the mills, shops, printing houses, factories; the stores of the small tradesmen; the almost innumerable places where electroliers are not used, but pendant or wall sockets fastened to the ceilings are. In all gas fixtures the burners turn vertically upward and the beauty of the fixture is always made subordinate to this fundamental requirement. Electroliers are different affairs, however, and great liberty of design is used, so that mostly but two things are kept in mind; artistic effect and convenience in wiring. The light distribution and illumination procured are scracely thought of except as suggested by the number of lamps installed. Go where you will, I am sure it will be found that my point is well taken.

When electroliers are used, shades are almost invariably put over the incandescent lamps and commonly intercept the brightest rays (those by which lamps are rated now) and do not reflect and redistribute them in nearly so effective a way as is generally supposed. A little numerical computation of any actual case (taking account of the real candle-power distribution and light cut off by shades) will show that under electroliers which have the lamps flared out with axes from 60 degrees to 30 degrees inclination down from the horizontal abundance of light is always found directly beneath the electrolier and a large candle-power out from the lamp tip helps to prevent a falling off in the illumination of the spaces midway between the light clusters. One never gets the 16 candle-power out from the side of a lamp to give light which is useful except in the very few cases where lamps are installed with their axes horizontal. In such cases very stiff lamp filaments have to be used and types giving large candle-power from the sides are the best.

Users of lamps rarely want a uniform distribution of light. In mills and factories, for example, concentrated light from lamps hung directly over machines on cord pendants is required. This is procured better by using a lamp with double-coil filament than any other means. Reflectors are indispensable to procure this concentrated lighting only if poor filament forms are used; but with proper filament forms they are much better omitted. Mirror reflectors or opaque reflectors are entirely valueless except in special lighting. Additional general lighting is always required where they are used, as anyone may see for himself by turning on his desk light alone, standing off and observing the lighting of his office. In a large room lighted by reflector lamps the gloom through all spaces around and above the lamps is peculiarly striking. Reflectors of porcelain have the same effects, but to a considerably less degree.

In short the whole question of the use of reflectors settles itself this way: If they are put on to help out the lighting no further evidence is necessary that more light than that commonly given in the direction the reflectors send light, is required. If a lamp filament can be constructed to give a satisfactory distribution without a reflector, not only a reflector is saved but a great advantage in general lighting is gained. If a shade be used on a lamp with properly shaped filament, it is only as an artistic setting for the lamp and serves no utilitarian purpose.

It should be very clearly understood that the good features of the double-coil filament lamp are the result of certain shaping of the filament alone—not of any change in the process of manufacture. Such a change is a very simple one to make. As compared with changes which any manufacturer would promptly make in his factory in order to turn out a reliable lamp of fair life at 2 watts per candle, a change of filament form is nothing. I do not suppose that in the future all forms of filaments except double-coil or similar filaments will be abandoned. The others will be still used in places to which they are adapted; in a word, they will be special lamps.

I am surprised that you should say that "making the candle-power given through the tip the standard measurement leads directly to the great drawback which is chiefly accountable for the rise of the alternating-current arc lamp and the decline of the more efficient direct-current arc lamp — namely, intense illumination approximately in line with the lamp axis and poor distribution elsewhere." Arc lamps all have to be installed with carbons in a vertical line and in such position the arc lamp gives no candle-power at all below it. The great defect of the direct-current arc is that one gets a very brightly-illuminated circle about the lamp, a black shadow below the lamp and dim darkness beyond the bright circle. Globes are put on arc lamps to redistribute the light so that part is refracted under the lamp itself as much as for any other reason. Alternating-current arcs have been successful mainly because they give less candle-power for a given number of watts and so contrasts of light and shade as one gets from lamp to lamp along a street are less noticed, and the lighting is pronounced more satisfactory, although the illumination at most points is considerably decreased.

Among the points which commend the "end on" measurement of candle-power for incandescent lamps may be mentioned these:

1st. It is the light which comes out from the end opposite the base and the region near it which furnishes the useful lighting in a vast majority of cases.

2d. The present commercial measurement of candle-power makes much of the light rays which rarely can be or are used to advantage, and a different method ought therefore to be used.

3d. The apparatus for making an "end-on" measurement of candle-power is very simple and within the reach of anyone.

Measuring candle-power from the end could never cause such reconstruction of filament forms that the horizontal candle-power would drop below a practical value. As things stand now, so much emphasis has been put on horizontal candle-power measurements that one form of filament gives only 30 per cent as much candle-power by "end-on" measurement as by a measurement taken "side on." Difficulties in construction would make it impossible to make so great difference in future forms that the horizontal candle-power should be so little as 30 per cent of the vertical.

This "end-on" measurement and rating must come. Common sense requires it; lamp users will demand it—are even now beginning to demand it. If the lamp manufacturers do not take the lead in the matter, lamp users, realizing full well the importance of the candle-power from the tip, will ere long specify the "end-on" measurement as the criterion by which the lamps to be purchased shall be judged.

Arthur J. Rowland.
Drexel Institute, Philadelphia, Pa.

AMERICAN STREET RAILWAY ASSOCIATION.

The nineteenth annual convention of the American Street Railway Association was called to order in Convention Hall, Kansas City, on Tuesday, October 16, by President John M. Roch. The usual address of welcome was made by Mayor Reed, of Kansas City, followed by the president's annual address and the report of the secretary and treasurer, after which a paper on "The Consolidation of Street Railways and Its Effect Upon the Public" was read by Daniel B. Holmes, counsel of the Metropolitan Street Railway Company, of Kansas City. After the reading of Mr. Holmes' paper the general meeting adjourned and an executive committee meeting was held.

On Wednesday morning the committee on nominations was appointed, after which C. F. Bancroft, electrical engineer of the Massachusetts Electric Companies, of Boston, read an interesting paper on "Comparisons of the Various Systems of Electrical Distribution for Street Railways." The systems compared were the standard 500-volt direct-current; the alternating-current transmission system with rotary converters to deliver direct-current to the railway lines; the booster system, which is simply the ordinary 500-volt system with boosters added to compensate for the line loss during extra heavy loads; the so-called three-wire system in which the two trolley wires form the outsides of the system and the rails the neutral conductor; the wholly alternating-current system employing alternating-current motors on the cars and the storage-battery system employing independent units, each car carrying a set of batteries. Mr. Bancroft summed up the comparisons by stating that each system had its peculiar advantages under different conditions and none were suitable under all conditions. Where traffic is heavy and the distance short he favored the 500-volt system; for suburban work the polyphase alternating-current transmission system with rotary-converters was recommended; in special cases where an ususually large amount of power is required for short periods of time the booster system was suggested; and for high-speed long-distance interurban work the wholly alternating-current system, he said, may be attractive. He pointed out, however, that the cars on the last-named system would have the disadvantage of not being able to run over the ordinary direct-current street railway lines. There was practically no discussion of Mr. Bancroft's paper, several members modestly declaring their inability to add anything to what had already been said. The secretary then read a paper by F. T. Brydges on "Re-Painting and Maintenance of Street-Car Bodies," Mr. Brydges being absent.

On Thursday morning a paper entitled "Double Truck Cars; How to Equip them to obtain Maximum Efficiency under Varying Conditions," was read by Col. N. H. Heft, president of the Meriden (Conn.) Electric Railroad Company. Colonel Heft stated that his experience with heavy and light motors mounted in various ways had shown that the maximum efficiency with minimum cost of maintenance was to be obtained by mounting two motors on each truck of a double-truck car, giving the car a four-motor equipment. If a two-motor equipment was to be used, it was preferable to mount both motors on one truck, making the other truck a trailer, for the reason that this method of mounting showed a saving in labor and cost of maintenance, although mounting one motor on each truck gave a higher efficiency of operation. Col. Heft expressed the opinion that controllers had not kept pace with motors so far as space and weight are concerned, and recommended the use of a pilot controller on the platform with some form of main controller underneath the car body. In the discussion of the paper J. I. Beggs stated that careful observations on a 350-mile system showed that four motors take more current than two motors, but the service with four motors is considerably better. They get better results, he said, from 150 horse-power divided into four motors under a car than with 250 horse-power in two motors under a car, but the four motors take from 20 to 25 per cent more current, running under exactly the same conditions.

After the discussion of Col. Heft's paper the election of officers was held and resulted as follows: Walton H. Holmes, president; H. H. Vreeland, first vice-president; M. N. Heft, second vice-president, J. B. McClary, third vice-president; T. C. Pennington, secretary and treasurer. The executive committee for the ensuing year consists of the president, vice-presidents and Messrs. John M. Roch, F. L. Fuller, George W. Baumhoff, John R. Graham and John Harris. The Association then adjourned to meet at the banquet on Friday evening, which was held at the Coates House.

Some Recent Electrical Patents

Protected Rail-Bond.—Electric railways are frequently subjected to the annoyance and inconvenience of having rail-bonds cut or removed by malicious or would-be humorous persons, especially in small towns and along out-of-town highways. In order to obviate this sort of trouble William A. Downing and James T. McHugh provided a protected form of rail-bond, which is illustrated by Fig. 1. The fish-plate is recessed, as shown in the lower part of the cut, for the accommodation of the rail-bond which it covers. In the upper part of the engraving the rail-bond is indicated by the No. 12. It is a flat strip with lugs at the ends and hangs on the two bolts which hold the fish-plate in place. Two small, stiff coil springs, marked 16, are provided for the purpose of forcing the bond tightly against the rails and maintaining good contact. The cross-section in the lower left-hand corner of the engraving shows all of the parts assembled. Patent No. 658,541.

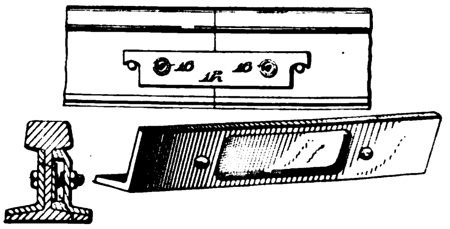

FIG. 1.—PROTECTED RAIL-BOND.

System of Train Control.—Occasion often arises for operating two or more electrically-equipped motor cars in a single train, when it becomes desirable to control the different motor equipments from a single point. With a view to providing this sort of control in a simple manner E. W. Rice, Jr., has devised and patented the arrangement shown diagrammatically by Fig. 2. The system here shown provides for the regulation of only two motor equipments. The two motors are indicated by the letters *MA* and *MB*, and are connected by a single wire, *W*, which runs the length of the train or less, according to the location of the two motor cars. The respective rheostats are marked *r* and *r*′; *S*1 and *S*2 are two-way switches with one contact omitted. With the switches in the positions shown, the two motor-equipments are obviously in series with each other and the motorman is supposed to be at the left-hand controller, *r*. It is obvious that resistance cut in at this point will regulate the speed of both motors; it is also plain that if the switch *S*1 be thrown to the right the two motors will be in parallel with each other and in series with the rheostat, *r*, the controller at *r*′ being, of course, in the "off" position. Upon leaving the controller, *r*, and going to the controller, *r*′ of the train, the switch *S*1 will be thrown to the right; then the motors would be considered in series with the controller, *r*′, and can be thrown in series or in parallel with each other by operating the switch, *S*2. Patent No. 11,852 (re-issue).

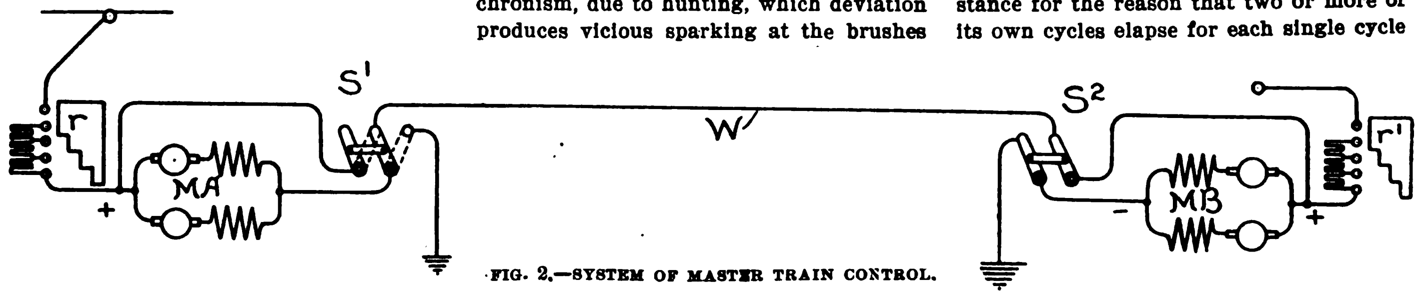

FIG. 2.—SYSTEM OF MASTER TRAIN CONTROL.

Insulation Transformer Test.—In order to avoid actually breaking down the coil of a transformer under the insulation test, A. R. Everest has devised and patented a method of testing which consists broadly of arranging an adjustable spark-gap across the secondary terminals of the step-up transformer which supplies the e.m.f. for the test. The adjustable spark-gap is, therefore, parallel with the dielectric medium in the transformer which is being tested, and can be set for any predetermined e.m.f., at or above which it will serve as a short-circuit to the insulation and prevent the puncturing of the latter. Patent No. 659,656.

Alternating-Current Rectifier.—The method of rectifying alternating currents by driving a commutator by means of a synchronous motor supplied from the same mains from which the current is taken to be rectified is, of course, well known, but it is also a matter of common knowledge that there is a tendency on the part of the motor to a deviation from absolute synchronism, due to hunting, which deviation produces vicious sparking at the brushes of the rectifying commutator. Fig. 3 illustrates diagrammatically an arrangement patented by Prof. Elihu Thomson for minimizing this difficulty. The rectifying commutator, which is shown supplying an arc-light circuit, is driven by the usual synchronous motor, 8, but this synchronous motor takes its current from a small alternator, 9, which is mounted on the same base and driven by the same shaft as the main alternator, 4. There is thus no electrical connection between the synchronous motor, 8, and the main alternator, 4, or any of its circuits. The small alternator, 9, is provided with a greater number of poles than the main alternator, 4, and the synchronous motor, 8, is provided with a similarly greater number of poles than it would have if it were driven direct from the main alternating circuit. The result is that the frequency in the local circuit between the small alternator and the synchronous motor is much higher than the main-line frequency. The object of this is to minimize the tendency to hunting, which decreases, of course, with an increase of frequency. Moreover, the motor, 8, although driving the commutator in synchronism with the alternations in the main circuit, on account of the greater frequency in its supply circuit cannot produce much of a deviation in the angular position of the rectifying commutator at any given instance for the reason that two or more of its own cycles elapse for each single cycle in the main circuit; that is to say, any angular deviation from true synchronism on the part of the motor will produce a much smaller deviation on the part of the commutator, because of the difference in frequency. Patent No. 655,032.

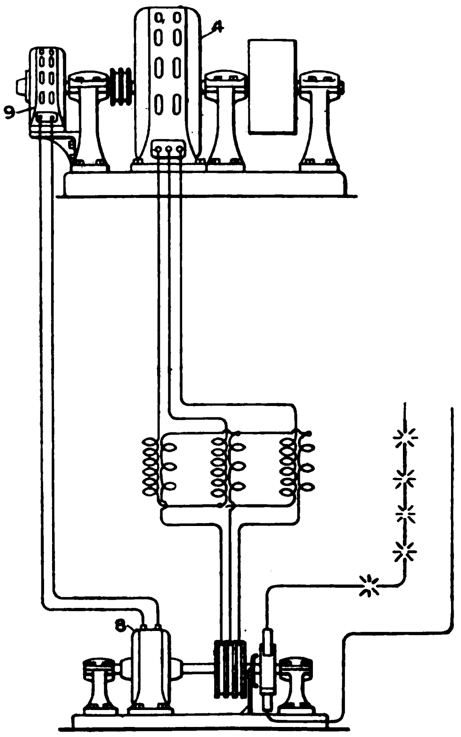

FIG. 3.—ALTERNATING CURRENT RECTIFIER.

NOTES.

A Five-Cent Telephone Rate for Chicago.—According to a press dispatch the Chicago Telephone Company has just announced a reduction in the rate of service for pay-station telephones from ten to five cents. The company has begun the work of installing new five-cent slot machines and expects to put one in every store or residence from which there is a prospect of a minimum of one service a day.

Electrical Equipment for the Rock Island Arsenal.—The United States arsenal at Rock Island, Ill., is to be equipped with a three-phase power-distribution plant for the operation of the various machines about the arsenal. The generator e.m.f. will be 550 volts, so that no transformers will be used. A novel feature of the plant will be the use of circuit-breakers in all three legs of each circuit. As there are to be 61 circuits, this means that 183 circuit-breakers will be installed.

The Horrid Mean Things.—According to a recent press dispatch from Louisville, Ky., the Cumberland Telegraph and Telephone Company has issued an order requiring telephone operators to furnish a bond of $25 as a guarantee that they will not use the telephone lines for personal purposes. This order, it is said, was made necessary by the fact that a number of the operators were accustomed to use the lines for gossiping and for conversation with male friends. The state of mind of the telephone girls is infinitely easier to imagine than to describe.

A Tardy Awakening.—The coroner of Toledo, Ohio, in a verdict rendered in the case of a man who was killed in the cellar of his place of business by an electric-light wire recently, urgently recommends the passage of an ordinance to create the office of city electrician, the person occupying such office to be empowered to establish rules and regulations concerning electric wiring and appliances. It is rather a matter of surprise to find that a city the size of Toledo is without a city electrician, and while the coroner's recommendation will not afford much comfort to the relatives of the unfortunate victim in this case, it is to be hoped that it will bear immediate and efficacious fruit.

Annual Meeting of the Automobile Club of America.—The annual meeting of the Automobile Club of America was held on October 22 at the club's headquarters in the Waldorf-Astoria Hotel, New York. The election of officers resulted as follows: A. R. Shattuck, president; Albert C. Bostwick, first vice-president; J. Dunbar Wright, second vice-president; David Wolfe Bishop, third vice-president; Jefferson Seligman, treasurer, and Malcolm W. Ford, secretary. Although the club has only been established a little over a year the membership is 262, and club affiliations have been established with the automobile clubs of Great Britain, France, Belgium, Switzerland, Berlin, Vienna and Turin.

Electric Power for Gold Dredging.—The first electrically-driven plant for the recovery of gold by the dredging process has recently been introduced into Victoria, Australia. The plant consists of a 500-kw. two-phase Stanley alternator from which current is transmitted about one-half mile by overhead construction to two barges, each barge containing a 50-h.p. motor driving a Wallace-Hedley gravel pump and a 150-h.p. motor for the hydraulic pumps. The motors drive their pumps through friction clutches and a rope drive.

Electric Traction in Moscow.—The Municipal Council of Moscow has just decided on the extension of its present system of street railways, and also on the transformation of those lines that are now worked by animals, into electric traction systems. The extension will be about 96 1/3 miles and the cars will be run at an average speed of 12½ miles an hour. The trolley system will be the one adopted in almost every quarter of the city, with the exception of certain parts, where accumulators will be used. The time allowed for the completion of the work is five years. At Riga, another town in Russia, the construction of an electric tramway has also been authorized by the government, the necessary expenditure for which is estimated at $800,000.

The Last Straw.—According to the Detroit Free Press, an imported domestic in one of the Detroit's prominent households has delivered an ultimatum on the subject of telephonic duties. The mistress of the house, after an absence of a few hours, recently asked the unsophisticated one if anyone had called her up on the telephone. She replied: "Indade they did, mum. The box jingled an' a lady wid a voice like a coffee mill says, 'Hello,' an' I says, 'Hello yerself,' an' she says, 'Who is this?' an' I says 'None of yer business.' An' she says, 'Is Aunt Mary there?' An' I told her she'd betther ask a policeman, an' she foired sumthin' in my ear, an' I dared her to show the ugly mug of her back of our barn an' she said nuthin'. I'll talk in that machine no more, mum!"

Standard Abbreviations for Metric Units.—The International Committee on Weights and Measures at the Paris Exposition adopted the following abbreviations of the metric units: Length—Kilometer, km.; meter, m.; decimeter, dm.; centimeter, cm.; millimeter, mm.; micron, μ. Area—Square kilometer, km²; hectare ha.; are, a.; square meter, m.²; square decimeter, dm.²; square centimeter, cm.²; square millimeter, mm.². Volume—cubic meter, m.³; stere, s.; cubic decimeter, dm.³; cubic centimeter, cm.³; cubic millimeter, mm.³. Capacity—Hectoliter, hl.; decaliter, dal.; liter, l.; deciliter, dl.; centiliter, cl.; milliliter, ml.; microliter, λ. Weight—Tonne, t.; quintal metrique, q.; kilogramme, kg.; gramme, g.; decigramme, dg.; centigramme, cg.; milligramme, mg.; microgramme, γ.

Chicago Electrical Association.—The papers announced by the Chicago Electrical Association for the fall and winter meetings are as follows: Nov. 16, Incandescent Lamp Photometry, by W. B. Hale; Dec. 7, Charles Wirt, of Philadelphia, on a subject to be announced later; Dec. 21, Electrical Features of the Paris Exposition, by J. M. Hollister, representative of the Western Electric Company at the Paris Exposition; Jan. 4, Electricity in the Equipment and Construction of a Ship, by C. C. Mattison; Jan. 18, Standardization of Arc Lamps, by Harold Almert. The meetings of this association are held on the first and third Friday evenings of each month at the rooms of the Western Society of Engineers, 1736-1741 Monadnock Block. The association has enjoyed a steady growth since its inception, and the coming year promises to follow the precedent already established.

Competition for the Invention of Insulated Gloves.—The Association des Industriels de France Contre les Accidents du Travail of Paris, has organized an international competition for the best and most practical insulated glove to protect the hands and forearms of electrical workmen. The gloves must be durable and able to resist not only the electrical potential, but also any accidental perforations caused by their coming in contact with the sharp ends of wires, etc.; must be easily carried about, and must enable the wearer to use them with as little inconvenience as possible. Persons desiring to enter their names on the list of competitors must do so before December 31, 1900. Correspondence should be addressed to the President of the Association at No. 3 Rue de Lutece, Paris, and two pairs of gloves will be required from each contestant. A prize of 1000 francs ($200) will be awarded to the person whose glove is adjudged the best. In case of two or more gloves being of equal merit the prize will be divided.

The Passing of a Pioneer.—A writer in a Texas paper, who evidently possesses a keen sense of humor, describes at length the relegation to the scrap heap of an old Heisler alternator. The obituary narrative, which is far from mournful, winds up as follows: "New machines have been for some time in use in the plant, but the old Heisler has held its post and as it observed more up-to-date machines placed around to do its work it has been meaner and more obstreperous than ever. This morning the manager left for his summer vacation; the train had barely passed out of the yard when there was a conference of employees, who seemed to have murder in their minds and mischief in their eyes. Kelly seized a monkey wrench and all hands set about 'chisting' the Heisler; in a short time the once wonderful machine was reduced to junk. The old Heisler is dead and its remains rest in 'pieces.' There were no mourners at the funeral and the boys feel that the customers will join the chorus of rejoicers and be exceedingly glad."

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Changes in advertisements should reach the office of the American Electrician by the 15th of each month in order to appear in the following issue. New advertisements can be received up to the 25th of each month.

IMPORTANT NOTICE.

Intending subscribers are warned not to place subscription orders with persons who cannot show written authority to take such subscriptions and make collections therefor, as the paper will not undertake to fill orders placed with alleged agents acting without such written authority.

Subscribers requesting a change of address should invariably furnish both the old and the new address.

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The American Electrician has a larger paid subscription list than any other electrical journal in the world.

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To Inquirers.

Notwithstanding the paragraph in italics which appears at the head of the first column on the Queries and Answers page, we are constantly receiving letters of inquiry to which a mail reply is impossible, because the writers have given inadequate addresses or none at all. It is the policy of the editorial department to reply by mail to all inquiries, regardless of their character; only those of probable interest to the general majority of readers, however, are published. Consequently, the receipt at this office of an inquiry of a special nature signed merely with the writer's name, and bearing no street address, results in a failure on the part of the writer to receive a reply. Several times recently we have attempted to get replies to inquirers who gave only the names of the cities in which they lived, with the natural result that the letters were returned by the postal authorities.

Poor Incandescent Lighting Service.

It seems rather paradoxical that while the design and construction of apparatus has been perfected in detail to an exhaustive extent, the methods of distribution and operation should remain—well, say careless, to a ridiculous degree. One finds central stations of fair size in which wiring is laid out (roughly at best) for one kind or volume of service and used for some other kind or volume, or both. And there are other stations where the distribution is of such a character that lamps of four or five voltages are in circuit because the use of a single voltage, or even two, means excessive renewals if the remote lamps are run up to candle-power. There is still another class of plant—we know personally of several cases—where only one voltage is used and the pressure is maintained normal at feeder ends, the more remote lamps presenting the attractive appearance of an aggregation of red-hot hair-pins or coiled wire springs. In view of these facts it is no wonder that the condition of affairs noted by Mr. Sonneberg in another column, should exist; it would be little short of miraculous to find any other results than slow growth or paralysis of incandescent lighting service.

These reflections apply to stations of medium and small size, of course, but there is no good reason why these plants should be operated in a haphazard manner. Any station superintendent of average intelligence can correct a condition of poor distribution by making a few tests of voltage at different points, laying out a diagram of his circuits to scale, and reinforcing the system where the chart indicates a deficiency in copper. When there are segregated groups of lamps at unusual distances from the station, it may be good practice to use lamps there of slightly lower voltage than the standard in order to avoid excessive expense for feeders, but the instances in which this is actually justified are comparatively rare. And on a network serving an ordinarily compact area there is not the least excuse for the practice of "tapering" the voltage of the lamps to meet a fall in potential along the lines. It is a clumsy evasion unworthy any engineer or superintendent who pretends to take an interest in his work.

Electric Elevator Control.

The number of safety attachments devised for the purpose of preventing a loaded elevator from running away with its motor is legion; the merits of most of them are also legion—on paper. Without meaning to carp, we share to a large degree the opinion expressed by an old engineer to the effect that automatics of all kinds require a man to watch them all the time to see that they work, should the occasion arise. This is a manifestly extreme statement of the case, and yet how many, many accidents occur which would not have happened had not some automatic complication hung fire at the critical moment. However, uncertain protection is usually better than none; its chief danger lies in the placing of complete reliance upon its efficacy.

The arrangement described elsewhere in this number impresses one as being ingenious and well worked out, involving only one moving part and a few contacts of a substantial character. The objection to all electrical automatics, however, is that their operation depends upon the integrity of several conductors and connections, the failure of any one of which will render the safety mechanism inoperative; indeed, in many cases the failure of one or two connections converts the apparatus into an element of danger. There does not appear to be any reason why an elevator motor cannot be so designed as to automatically brake the descent of the cage immediately beyond the point of normal speed, without the employment of auxiliary mechanism. Such a condition would require that the field strength of the motor be stronger when the cage is descending than when it is being hauled up; in other words, the motor armature would need to precisely balance the impressed e.m.f. from the line when driven as a dynamo at the same speed of rotation that it normally takes as a loaded motor, or perhaps at a slightly lower speed. Then any increase in speed would result in delivering energy to the supply circuit and braking the elevator travel.

That automatic devices should be provided goes without saying. No elevator system should be permitted to operate without at least one auxiliary safety device to guard against excessive downward speed. But such devices should not be of such a character that any disarrangement of them can interfere with the normal operation of the motor or tend to remove control of it from the attendant, unless such removal brings the machinery to a stop. And the motor should be so designed, as above suggested, that it will inherently oppose any tendency toward excessive speed on the part of the cage. It may be urged that the capacity of the motor as a brake-dynamo can easily be exceeded by the load on the elevator. Such a condition means criminal overloading of the outfit which ought to land the persons responsible for it in a penitentiary.

Calorimeters and Calorimetry.

Central station engineers who have "never thought much about" making calorimeter tests of their steam have probably thought considerably about the discrepancy between the kilowatt-hours they are getting at the switchboard for each pound of coal burned under the boilers and the results obtained in more carefully managed stations. It behooves all engineers who come within this designation to read studiously the article on the calorimeter which appears on another page, and the one on calorimetric testing which will follow next month. The author of these articles is a recognized authority on steam engineering, and the articles under discussion have been prepared especially to meet the needs of central station men.

It is not sufficient to blindly cover steam pipes and stick separators in, in the belief that having indiscriminately done these things nothing else remains. There are plants supplied with pipe covering and separators that will show from 4 to 8 per cent of moisture under a reliable calorimeter test. Such tests are by no means easy to make accurately, but it is nevertheless essential that they should be made if a steam plant is to be worked at its maximum efficiency. Mr. Nagle's articles will be found of great value to both the engineer who is and the one who is not accustomed to make moisture tests of the steam delivered to his engine.

The Rating of Incandescent Lamps.

On another page will be found under the above heading a communication from Prof. Rowland with reference to our remarks last month on the subject of standard ratings for incandescent lamps. Although any discussion of a polemical character is distasteful, some of Prof. Rowland's statements impel a controversion. The difference of opinion as to the position in which the majority of lamps are hung is of small moment; as we intimated previously, the assumption that *all* lamps are hung perpendicularly would not afford a basis of support for "end-on" rating. On the contrary, lamps so hung and rated by "end-on" measurement would project a strong light directly beneath them and leave the areas between lamps in a state of uncertain illumination which might be deliciously conducive to an exchange of sentimental declarations, but fatal to any utilitarian purpose. Prof. Rowland's statement that "users of lamps rarely want a uniform distribution of light" will not find endorsement among central station men who have to daily face the problem of lighting dry goods and clothing stores, groceries and other shops, the proprietors of which expect a handful of lamps to brilliantly illuminate every nook and corner of the place.

Did we not believe him above such procedure we should say that Prof. Rowland had resorted to quibbling in discussing the subject of arc lamps. Last month we said that direct-current arc lamps gave "intense illumination *approximately* in line with the lamp axis and poor distribution elsewhere." Prof. Rowland carefully corrects this by explaining that the great defect of the direct-current arc is that "one gets a bright circle about the lamp, a black shadow below the lamp, and dim darkness beyond the bright circle." We are unable to detect any difference between the spirit of our proposition and that of Prof. Rowland's. Neither is accurately expressed, but only a literary purist or an etymological fanatic could fail to construe both to mean that most of the rays from a direct-current arc are concentrated in a comparatively restricted area near the lamp and below the level of the arm, the distribution between lamps being poor.

This is precisely the general effect that would be obtained with incandescent lamps rated by "end-on" measurement, except that the shadow cast by the arc lamp carbon and globe holders would, of course, be absent. This, however, would not help the poor intermediate distribution and it seems obvious that this defect would militate as strongly against incandescent lamps rated by "end-on" measurement as it has against the direct-current arc lamp. Prof. Rowland meets this argument with the statement that users of lamps rarely want a uniform distribution of light and this seems to be the point upon which any exchange of argument on the subject must hinge. The question of distribution is obviously determined by the individual requirements of each user of lamps. It is undoubtedly true that there are many cases in which the user would prefer to have the lamp give its maximum candle-power through the tip, such as industrial establishments where bright light is not required except immediately upon the work being performed. That this class of incandescent lamp users constitutes anything approaching a majority of the whole does not seem within the bounds of reason when one considers the myriads of salesrooms and shops which require all the light they can get on every inch of superficial area.

It must not be understood by any means that we condemn Prof. Rowland's proposed standard of measurement; but we certainly cannot approve it unconditionally, either. The present method of rating gives a lamp that is deficient in vertical candle-power; Prof. Rowland's method would inevitably produce a lamp deficient in horizontal candle-power. Unquestionably, neither result is wholly satisfactory. But the present lamp has the advantage that its vertical deficiency can be corrected by means of reflectors, whereas the horizontal deficiency of Prof. Rowland's ideal could not be overcome by a reflector without a deliberate and prohibitive sacrifice of light on one side of the lamp. Possibly a compromise between the two extremes would give good results, namely, a lamp giving maximum candle-power vertically or horizontally and, say, 75 per cent of the maximum in the other direction. This, however, involves two distinct photometric measurements, which nullifies the best claim for "end-on" rating.

DESIGN FOR A 1-H P. SINGLE-PHASE INDUCTION MOTOR.

BY J. C. BROCKSMITH, M. E.

Continuing the designs for single-phase motors, the present article deals with the construction of a 1-h.p. machine. The machine is similar in its general features to the ½-h.p. motor described in the previous issue, and has six poles, so that its synchronous speed is 2500 r.p.m. on single-phase circuits of 125 cycles and either 50 or 100 volts. Modifications will be shown, however, which will enable the machine to be used also on 60-cycle circuits at the same rated output which it has on the higher frequencies.

Fig. 1 shows an end view of the primary or stator core. There are 36 slots, each ⅜ in. wide and ¹¹⁄₁₆ in deep, with rounded ends. The core may be built up of plain round punchings about No. 27 gauge and the slots drilled through templates in the manner already described for the smaller machine. Fig. 2 is a section through the stator core, showing the arrangement of the screw rods for clamping the discs. Six ⁵⁄₁₆-in. rods of cold-rolled steel are used; they are provided with a screw thread at each end and a special round nut slotted to permit tightening by means of a spanner wrench or screw driver. The punchings are retained by a pair of brass flanges, the rods being insulated both from the core and from the brass end plates by means of fiber tubes and washers. The iron discs are also given an individual insulation of either japanning or paper and shellac before being finally built up in the core.

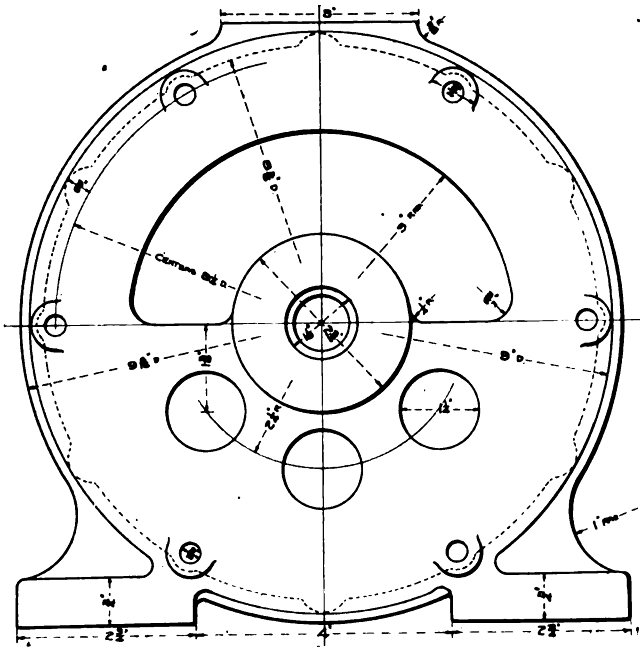


FIG. 3 —END PLATE OF MOTOR.

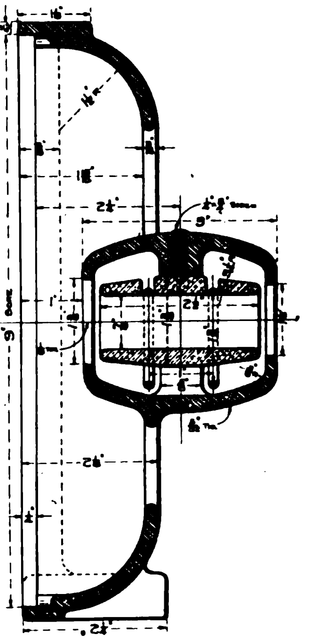


FIG. 4.—SECTION OF END PLATE AND JOURNAL BOX.

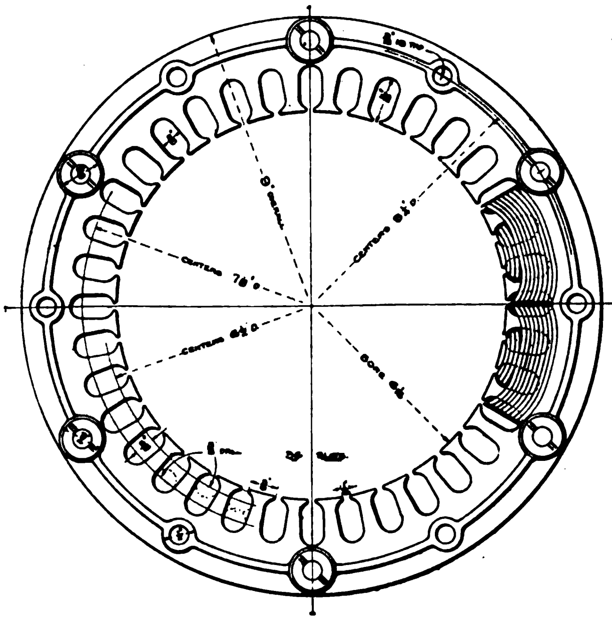


FIG. 1 —END OF STATOR.

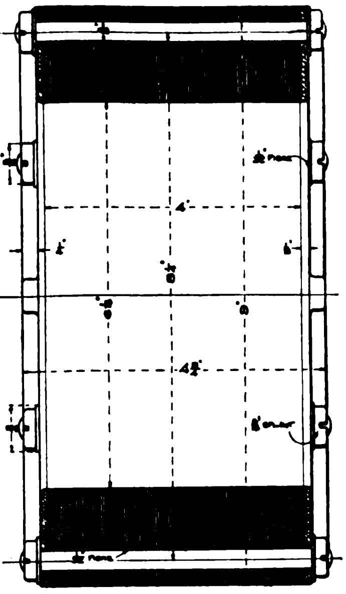


FIG. 2.—AXIAL SECTION OF STATOR.

Fig. 3 shows an end view of the end shield and bearing. This is cast with ventilating openings at the top and bottom and is recessed at the back as indicated by the dotted lines to allow the casting to fit closely upon the primary core without interference with the nuts and projections thereon. Six ⁵⁄₁₆-in. × 1½-in. hexagon cap screws fasten the cover plate to the primary core. Fig. 4 is a section through the bearing which shows the arrangement of the sleeve and oil rings. These parts when finished are placed in position from the rear of the bearing shell, and a small cone-pointed screw is provided to prevent the sleeve from turning in its support. The sleeve and rings should be made of brass, while the cover plate may be of cast iron.

Fig. 5 shows a section of the rotor and pulley. The core is built up of laminated iron in the usual way, the discs being supported upon four-armed spiders which in turn are secured to the shaft by means of ⁵⁄₁₆-in. steel pins driven in after the pressure has been applied.

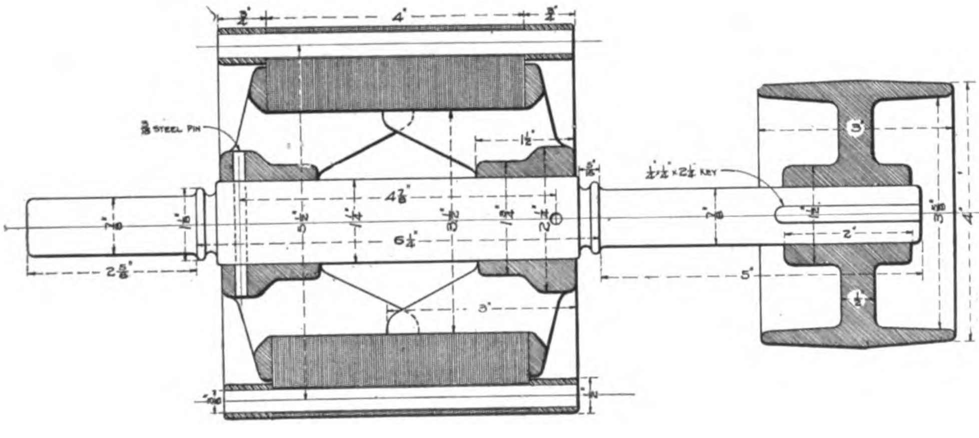


FIG. 5.—AXIAL SECTION THROUGH ROTOR AND PULLEY.

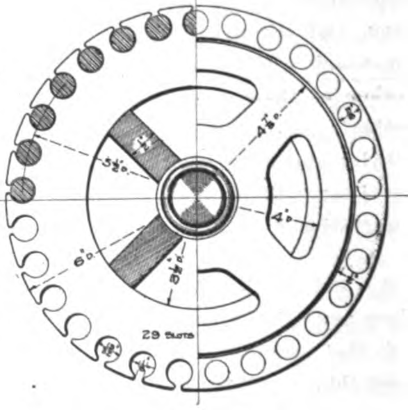


FIG. 6.—END OF ROTOR.

Fig. 6 shows an end view of the rotor, partly cut away to make clear the details of the slots. The discs are 6 ins. in diameter with a 3½-in. hole in the center, and are drilled with 29 conductor holes $^{13}/_{32}$ in. in diameter. This allows $^{1}/_{64}$ in. of insulation between the ⅜-in. conductors and the core. The secondary conductors are composed of ⅜-inch copper rods 5½ ins. long, and are soldered into heavy copper rings at each end. The rings may be copper castings, turned to size and drilled to receive the rods. It is preferable in assembling the core to spiral the slots slightly, and if this is done the rings must be drilled on a slight angle to correspond.

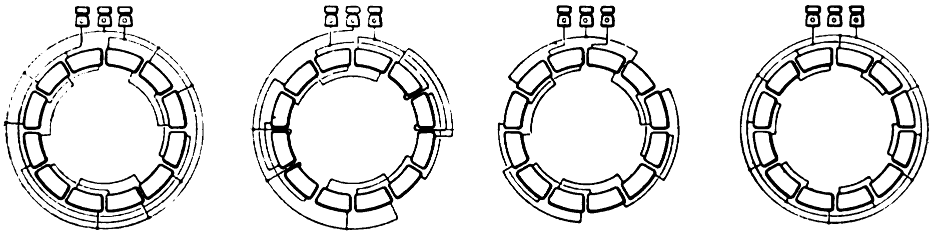

50 volts, 125 cycles. 6 poles, 2500 r. p. m.
100 volts, 125 cycles. 6 poles, 2500 r. p. m.
100 volts, 60 cycles. 6 poles, 1200 r. p. m.
50 volts, 125 cycles. 12 poles, 1250 r. p. m.

FIG. 7.—VARIOUS FIELD CONNECTIONS.

When all machining of the various parts of the motor has been finished, the primary core should receive its winding of wire. This consists of 12 coils of No. 14 B. & S. double-cotton-covered magnet wire, 36 turns per coil. The coils should occupy positions as shown in Fig. 1, where two of them are represented in place. Each slot is first insulated—with heavy cotton "drilling," oil paper, or similar material—and there will then be ample space to put in 24 No. 14 wires. Each coil occupies two adjacent slots and a half of each of the slots next to these. Where two coils meet in the same slot they should be separated by a strip of insulating material, preferably mica.

The coils having been wound, they may now be connected as shown in the diagrams, Figs. 7 and 8, which show arrangements for 50 or 100 volts and 60 or 125 cycles. Other voltages slightly higher, such as 52 or 104, or even 110, could be used without injury to the machine. For still higher voltages of 200 and upward the machine may be operated with an auto-transformer of one-half the capacity of the motor, or directly by connecting all the primary coils in series.

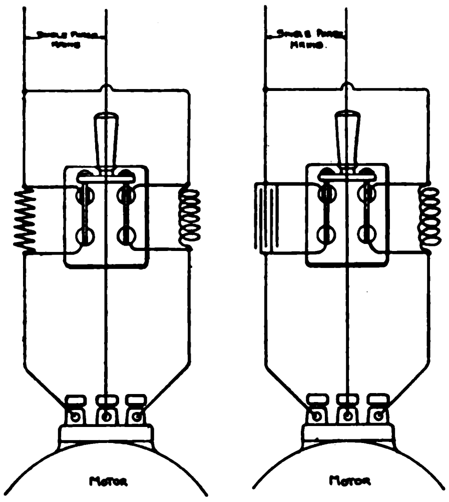
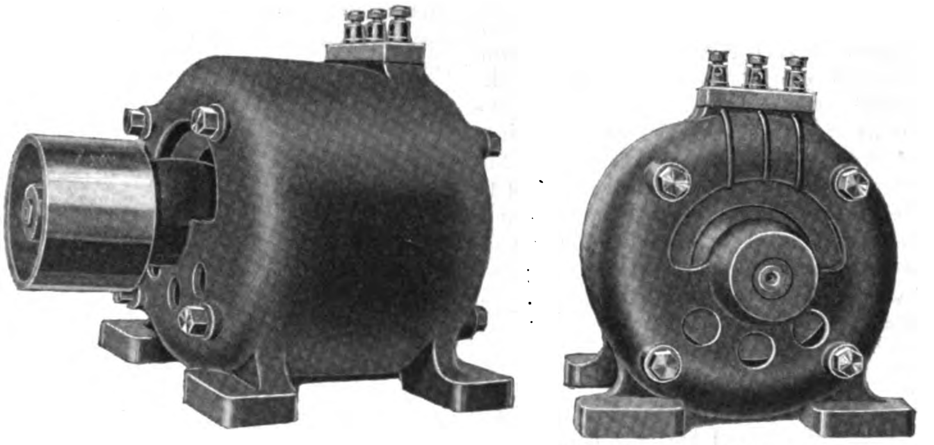


FIG. 9.—PHASE SPLITTERS.

Instead of the winding above described the core may be wound with a distributed winding of 36 coils, each spanning one-sixth of the inner circumference of the core. Such a winding, if provided with taps at proper intervals, would permit of working the motor on two-phase or three-phase circuits as well as on single-phase circuits, but it would entail the disadvantage of requiring the use of rather heavy wire, which would be difficult to wind in such narrow slots.

The starting arrangement to be used with this machine is a phase-splitter, such as was described in connection with the ½-h.p. motor in the previous issue. (See Fig. 9.) The phase-splitter should be proportioned for ordinary work to take a current of 15 to 20 amperes on the 100-volt circuit, which will start the machine with about one-half the full-load torque. The fall of potential over the two different sections of the phase-splitter should be equal.



FIGS. 10 AND 11.—SIDE AND END VIEWS OF COMPLETE MOTOR

The phase-splitter is not operative with any connection giving more than six poles, but the motor may be used with 12 or more poles, if started by hand.

Figs. 10 and 11 are respectively side and end views of the complete motor. These views are added merely to give an idea of the general appearance of the finished machine. The following is a brief summary of the important dimensions of the motor and the data for winding:

Six poles; 2500 r.p.m. at 125 cycles or 1200 r.p.m. at 60 cycles.

Efficiency 70 per cent. Power factor 65 per cent at full load.

Full load current (50 volts) $= \frac{746}{.65 \times .70 \times 50} = 33$ amperes.

Armature 6 ins. diameter; 4 ins. long.

Peripheral velocity $= \frac{6 \times P \times 2500}{12} =$ 4000 ft. per min.

Bore of field $6^{1}/_{16}$ in. Air-gap $^{1}/_{32}$ in. Primary slots, 36, each ⅜ in. × $^{11}/_{16}$ in.

Primary wire No. 14; diameter over insulation 76 mils; area 4107 circ. mils, or 745 c.m. per ampere; 12 coils, 2 coils in series on 50 volts and 125 cycles; 24 wires per slot. Thirty-six turns per coil. Weight of wire on primary $= \frac{10 \times 36 \times 12 \times 12.5 \times 1.088}{12 \times 1000} = 4.9$ lbs.

Total lines per pole, $\Phi = \frac{50 \times 10^{8}}{4.44 \times 72 \times 125} = 125{,}000$. $B_{max.} = 21{,}000$. Iron dimensions 4 in. × 1⅛ in. Secondary slots, 29, each $^{13}/_{32}$ in. diameter, round. Secondary conductors, ⅜ in. copper rod, 5½ ins. long. Total length of secondary conductor $\frac{5\frac{1}{2} \times 29}{12} = 13.3$ ft. Weight of copper in secondary rods and connectors, 7.3 pounds.

◆

GROUNDING THE NEUTRAL OF A THREE WIRE SYSTEM.

It is usually considered advantageous to ground the neutral of large three-wire systems, although the practice is not extended to small systems. The advantages are two in number. In the first place, if the neutral is grounded it is never possible to get a shock between any wire and the ground of more than 110 volts. If the neutral is not grounded the positive may become accidentally grounded at any time, in which case defective wiring in a socket or any other common fault may give some user of lamps a 220-volt shock between the negative and ground, which, as everyone knows, is a good deal worse than a 110-volt shock. Similarly, if the neutral is grounded there is no risk of the strain of 220 volts being established between the weak or wet insulation of the wires and nearby piping or other ground, where 220 volts might start a fire while 110 would not.

The other advantage of grounding the neutral is the reduced risk of blowing neutral fuses. Care should be taken in all three-wire systems that the neutral fuse in any cut-out is not blown, leaving the positive and negative fuses in. If this does ocur many lamps fed through this cut-out are bound to be burnt out, since more lamps are sure to be on one side of the system than the other and the side with the fewest lamps will get an abnormally high potential, burning the lamps out.

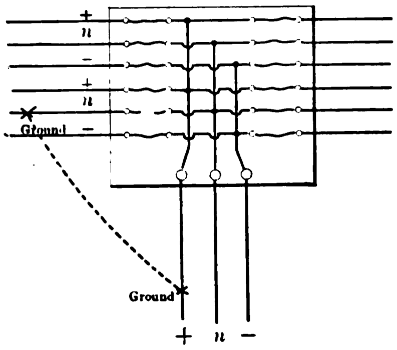


FIG. 1.

To show how grounding the neutral reduces the risk due to blowing fuses, consider the accompanying diagrams. Fig. 1 is typical of three-wire distribution throughout the system. If the neutral is not grounded at the dynamo and the positive feeder becomes accidentally grounded at a point protected only by a large fuse, a second ground on a neutral branch wire will result in the blowing of the branch neutral fuse, assuming that the neutral is more lightly fused than the positive and negative leads. The positive and negative branch fuses will remain in and the two grounds will short-circuit the positive side of the system, leaving the lamps on the negative side of the grounded branch neutral subjected to the full 220 volts, the result of which need not be described. If the neutral were permanently grounded at the dynamo any accidental ground on the positive or negative lead of the system will blow a positive or negative fuse and no lamps will be injured. Even where two-wire branch distribution is employed, as in Fig. 2, it is entirely possible for the neutral branch fuse to be blown by the two accidental grounds, leaving the positive fuse in, which will give the same condition as just described. The disastrous results due to two such grounds can be avoided, of course, by making the neutral fuses at all points slightly heavier than the positive and negative fuses, so that in the event of an accidental condition of affairs such as that illustrated the neutral fuse would be the last to go.

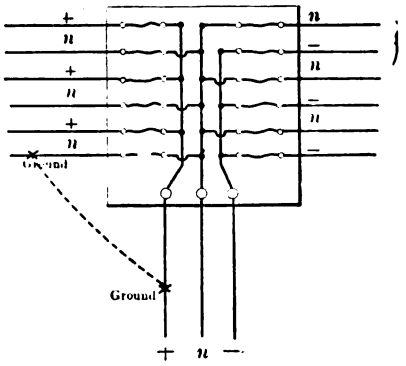


FIG. 2.

On small systems which can easily be kept clear of grounds and where grounds can be promptly located by means of a ground detector and cleared up before other grounds occur, it is not advisable to permanently ground the neutral, because if the neutral is grounded a single other ground causes a short-circuit and the blowing of one or more fuses, while if the neutral is not grounded a single accidental ground does not cause immediate trouble and may be cleared before a second ground occurs. On very large systems with extended underground mains the leakage through the insulation of Edison tubes becomes sufficient to cause a considerable ground, enough to blow fuses if other grounds occur. It is impossible on such systems to make any use of a ground detector on account of the leakage. On this account large systems customarily work with grounded neutrals.

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DIRECT-ACTING DAMPER REGULATORS.

BY JAMES F. HOBART.

In the direct-acting damper regulator there is a disc of sufficient area to enable the steam pressure acting thereupon to operate the damper. The disc is made tight to its steam chamber by means of a diaphragm, clear connection being maintained at all times with the interior of the boiler by a small pipe which has no openings except in the regulator and in the boiler. Sometimes this pipe is connected with the glass water gauge, but this is poor practice, for a failure of the diaphragm will put the water column out of commission, temporarily at least. In the direct-acting pressure regulator, there can be no movement of the damper until the steam pressure has increased to a point which overcomes the inertia and friction of the entire apparatus; therefore, the device is very slow to act, especially when subjected to only small variations of steam pressure. When the pressure is falling the sluggishness is worse, if possible, than under rising pressure; the steam pressure may fall so quickly under a sudden demand for steam that serious inconvenience arises before the slow-going damper can respond to the demands made upon the boiler.

The direct-acting diaphragm damper regulator is made by many concerns. Several types of direct-acting damper regulators are very interesting in their action, and display a good deal of ingenuity in the manner in which the mechanical difficulties are overcome. In one of these regulators, the Fairburn, made by The Fairburn-Seagrave Company, Boston Mass., and represented by Fig. 6, the diaphragm pressure does the work of handling the damper through a very ingenious device whereby the movement of the diaphragm is multiplied several times before it is applied to the damper. The multiplication is effected partly by the lever, m, and also by the differential wheels, n, which are so arranged that the movement of the damper will be the difference between the circumferences of these wheels. Movement of the lower quadrant by the lever, m, starts the wheel, n, which really floats up and down, being attached only by the two chains as shown, and moves the damper through a space depending directly upon the amount of increase or decrease of steam pressure. The two levers shown loaded with weights, and extending in either direction from the steam pipe, are merely for balancing the apparatus against any desired pressure that is to be maintained in the boiler.

There are damper regulators operated wholly or in part by steam pressure, and the two succeeding engravings show two of them. Fig. 7 represents the Gaston damper regulator, which was invented a few years ago by Stephen M. Gaston, Sherman, Texas. This appliance is very ingenious in its action. A pop valve constitutes the weighing mechanism, and by making the valve to blow into a cylinder to which the damper-actuating piston is fitted, the motive power for working the damper is secured by the same steam that is weighed by the pop valve. When the pressure rises so as to open the valve, the steam passed through that device causes the piston to ascend and close the damper. The regulation is given by the escaped steam itself. As it enters the cylinder it becomes compressed to a certain extent and consequently puts a back-pressure on the pop valve which stops its action, thereby preventing the damper from going to the limit of its travel. As the steam confined in the cylinder slowly condenses, it allows the piston to fall and the damper to open again. The load of weights shown at the bottom of the device serves to regulate the action of the device.

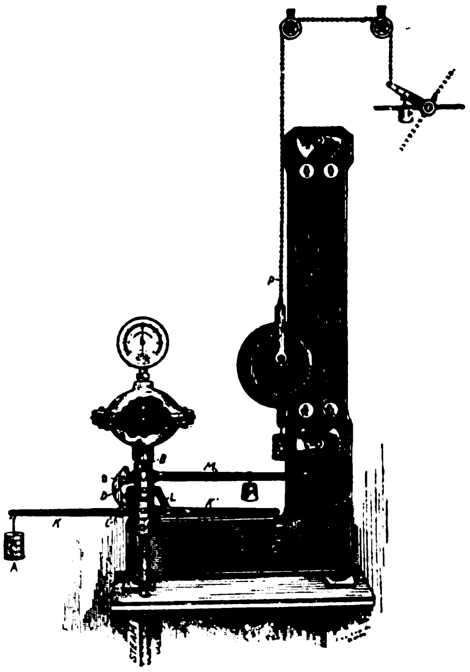


FIG. 6.—FAIRBURN DAMPER REGULATOR.

Fig. 8 illustrates a damper regulator which seems to be a combination of all the others. It is a steam damper regulator to a certain extent, as the regulator is connected by a single pipe direct to the steam space of the boiler and all the working of regulator and damper is done by the pressure through this pipe. Still, there is never any steam in the regulator, as the small condensation chamber shown in the steam pipe contains at all times sufficient water of condensation to keep all steam at a distance from the cylinder of the regulator. The working of the device is very simple. The lower portion of the frame contains a weight pan upon which are placed weights enough to secure a perfect balance of the steam pressure in the cylinder, and, consequently, in the boiler. As long as the pressure remains the same no movement takes place in the regulator. But let the pressure run up a little and the balance is destroyed, the piston is forced up and the damper closed. But here the ingenious feature of the contrivance comes in. As the piston rises, the chain at the bottom of the scale pan is lifted from the floor, link by link, and the constantly increasing weight establishes a balance before the damper has moved very far, thus preventing extreme travel. When the pressure falls the operation is reversed, of course, the chain being deposited on the floor link by link until the balance is restored. This apparatus is known as the American damper regulator, and is marketed by Harold C. Dayton, New York.

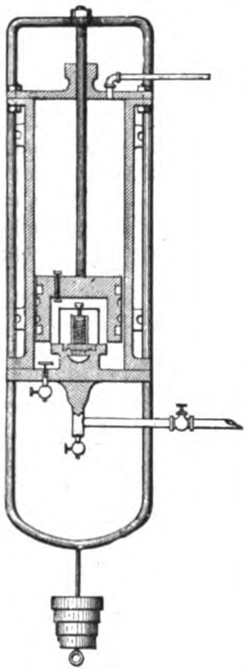


FIG. 7.—GASTON DAMPER REGULATOR.

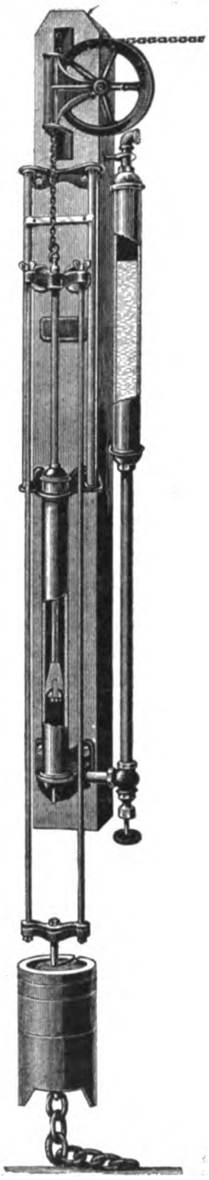


FIG. 8 – AMERICAN DAMPER REGULATOR.

THE WATER RHEOSTAT.

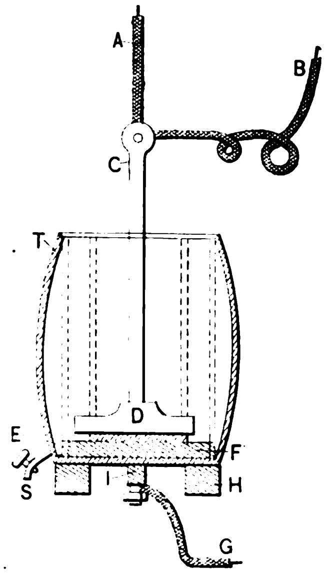
One of the handiest devices to have around a repair shop, power house, or test room is a water rheostat or water resistance. It is used the same as any other resistance, but is cheaper and of much wider range than any other sort of resistance of the same maximum value, and there is no danger of a burn-out. A very cheap form of water rheostat that takes up but little room can be made from a common barrel, as indicated by the accompanying engraving. In this illustration, F is the lower part of a trolley stand, the foot, turned upside down so that the part on which the base ordinarily turns sticks down through a hole in the bottom of the barrel; the part, I, that sticks through is drilled and tapped to take a ½-in. bolt. Between two brass washers strung on this bolt is placed the terminal casting, which is soldered on to the wire, G, that serves as one terminal of the rheostat. Into an iron plate, D, is screwed a piece of gas pipe, C, which is flattened out at the top and has a hole drilled in the flat part; through this hole passes a bolt which secures the end of the rope, A, by means of which the casting, D, is pulled up and down, and also holds one end of the wire, B, which serves as the other terminal of the rheostat. The rope, A, passes over a pulley in order to facilitate the adjustment of the plate, D.

The barrel is set upon two blocks, H, to raise the terminal, I, off the floor for easy access. A plate of fiber or wood, E, is fastened on top of the plate, F, or on the bottom of the plate, D, so that the two plates cannot actually touch each other and produce a short circuit. A spigot, S, is provided to draw off the water when it gets too dirty. It is evident that raising the plate, D, increases the resistance between the terminals, B and G.

It is well known that in course of time the iron plates used as electrodes are eaten away by the current. If the wire, B, is made the positive terminal the bottom plate is the one that gets the most of this action, so it should be made as heavy as possible. The connection between this plate and the terminal, G, is made outside of the barrel, so that it cannot be eaten off and can be reached without drawing the water out of the barrel. Both of the leads, B and G, should be of stranded wire to lessen the chances of their breaking off or getting loose.

In using a water resistance, it must be borne in mind that as the water becomes warm its resistance becomes less and the current more, so that until the resistance reaches a steady value it is not safe to go off and leave the circuit closed through any device that an excess of current will injure. Furthermore, where heavy currents are used the water foams considerably, and if the barrel is too full it is likely to slop over. Pure water has a high resistance and such a rheostat with the moving plate drawn up to the top of the barrel will let little or no current through, even if the terminals be connected right across a 500-volt line. After the current is on a while, however, the water contains grains of iron eaten off the plates, and the resistance is much lower.

If it is desired to reduce the resistance at once, put in a handful of sal ammoniac or of common table salt. Sal ammoniac will reduce the resistance a great deal and very suddenly, so that it must be put in carefully if there are any delicate instruments in the circuit; its initial effect is much greater than its permanent effect. On the other hand, common table salt does not have such a strong initial effect, but it holds its own. If coarse salt is used the permanent effect will be greater than the initial effect, because it takes the salt some time to dissolve. If the resistance of the water becomes too low with the plate, D, drawn as far up as it will go, it can be increased by drawing warm water out of the spigot and pouring cold water in at the top. In pouring the water in a wooden pail had better be used, as a tin one is likely to be the means of transmitting a smart shock.



WATER RHEOSTAT.

Once in a while all of the water should be let out of the barrel, the mud cleaned out, and fresh water put in. If during a test the current becomes unsteady, it indicates that there is either a loose connection below the surface of the water or that the plate, D, is pulled up so high that it makes poor contact with the water, so that the current is passing through the foam on the surface. The current capacity of such a water barrel can be increased a great many times by slipping a sleeve of boiler iron into the barrel so that it makes contact all around its lower edge with the plate, F, and putting a smaller sleeve over the pipe, C, so that it rests on and makes contact with the same plate. The dotted lines in the sketch show the position of these sleeves, which are almost as deep as the inside of the barrel and present a large surface for the current to go through.

The practical limit to the current capacity of a water rheostat is determined by the amount of foaming that the water does. If the current density becomes too great, the water foams throughout its body and the current becomes too unsteady; the water also foams out of the top of the barrel about as fast as it can be put in. Another way to increase the capacity of the resistance is to use two or more barrels in multiple and adjust the plates simultaneously.

A good water rheostat is useful in many ways. By putting one in series with the feeder that supplies the car house of a railway system, the number of controllers damaged by careless shifting can be cut in half. In such a case the house lights must tap on to the trolley beyond the barrel. By connecting the barrel in series with the trolley wire section from which the transfer table takes current the table can be made to start smoothly instead of jerkily. Properly disposed, it can be used to do any kind of plating. It is also handy to pass the current through when testing the polarity of fields or in testing two motors on a truck to get the connections so that they will run the truck the same way. It is also extremely useful in connection with motor and transformer tests in lighting stations.

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INTERIOR TELEPHONE SYSTEMS.

BY W. S. HENRY.

INTERCOMMUNICATING SYSTEMS.

In the systems so far described there is nothing to prevent the intercommunicating switch from being left off the home button when the conversation is finished and the receivers hung up. This is an objection that becomes more and more serious as the number of stations in the system and the forgetfulness of those that use the telephone increase. Several devices have been patented that either cause the intercommunicating switch to return to the "home" position when the receiver is hung up, or else prevent the hanging up of the receiver until the switch is manually returned to the home position, as previously noted.

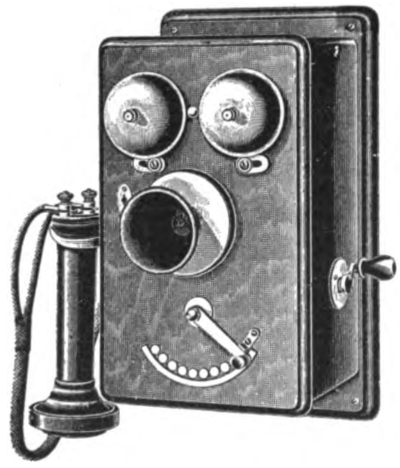

FIG. 30.—MAGNETO WITH NESS SWITCH.

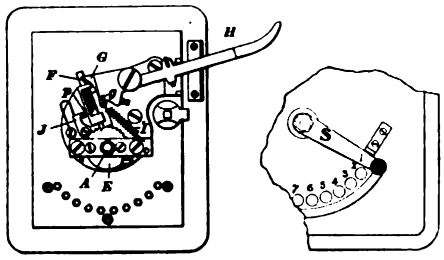

FIG. 28.—NESS AUTOMATIC SWITCH.

The Ness automatic switch, made by the Holtzer-Cabot Company, and illustrated by Fig. 28, is arranged so that the replacing of the receiver upon the hook causes the switch to fly back to its home position and so entirely overcomes the trouble due to the forgetfulness on the part of those using the telephones. In the engraving S is the lever of the selective switch, adapted to be rotated over the various contact buttons, 1, 2, 3, etc. It is mounted upon a shaft, A, passing through the front board of the box and carrying a ratchet wheel, E, inside the box. This ratchet-wheel is held in any position to which it may be rotated by a pawl, F, and thus prevents the lever, S, from turning backward. Upon the short arm of the hook lever, H, is pivoted a dog, G, adapted, when the receiver is removed from the hook, to engage a notch in the pawl, F; when the receiver is replaced, the dog, G, is pulled upward and lifts the pawl out of engagement with the ratchet-wheel, allowing a spiral spring around the shaft, A, to return the switch lever, S, to the home button. After raising the pawl out of the notch on the ratchet-wheel the dog slips out of the notch on the pawl, thus allowing the latter to return into contact with the ratchet-wheel in order to be ready for the next use of the telephone. In order, however, that the pawl may not engage the ratchet-wheel before the lever, S, has fully returned to its normal position, a second dog, J, is provided which is pressed by a spring so as to occupy a position under the pin, p, carried on the pawl, F, thus holding it out of engagement with the ratchet-wheel until the rotation of the lever is completed. At this point a pin on the further side of the ratchet-wheel pushes the dog, J, out of engagement with the pin, p, and allows the pawl, F, to drop into contact with the ratchet-wheel.

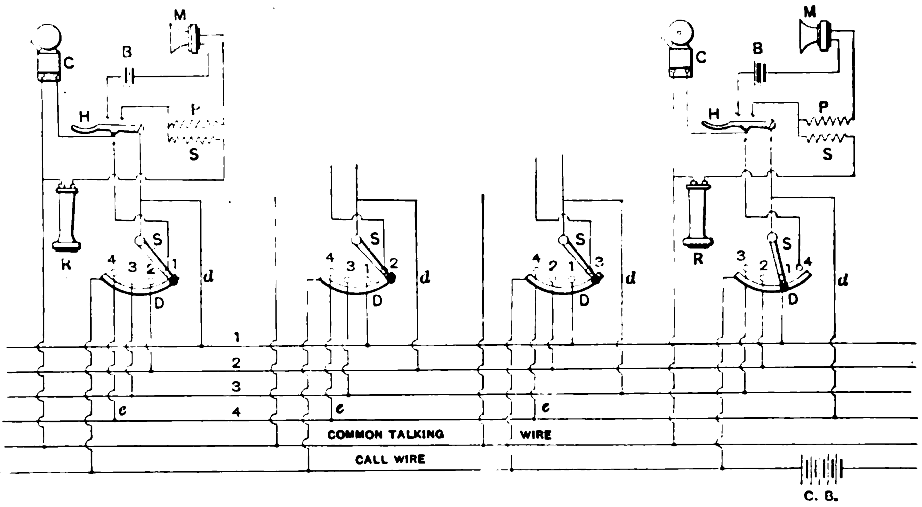

FIG. 29.—COMMON SIGNALLING BATTERY SYSTEM; INDIVIDUAL TALKING BATTERIES.

In Fig. 29 are shown the circuits of a four-station system using one common battery, CB, for ringing up the various stations, each station having an ordinary vibrating bell, C. The circuits of Stations 1 and 4 are shown in full, while those of the intermediate stations being exactly the same, are partially omitted. It will be noticed that the switch lever, S, at each station is connected with the line wire bearing the same number as that station, by means of the wire, d. Each line wire

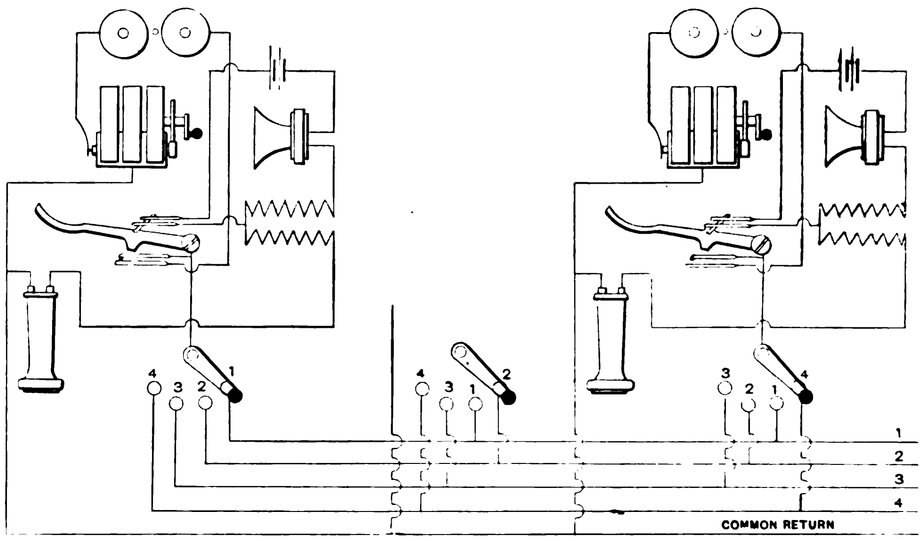

FIG. 31.—SYSTEM EMPLOYING MAGNETOS LIKE FIG. 30.

is also connected at each of the stations not bearing its own number with a button on the switch of that station which does bear the same number in the manner previously described, by means of the wire, e. In this common-battery call system two additional wires are run, one being termed the "call wire" and the other the "common talking wire." The call wire and the talking wire are connected through the calling battery CB, as shown. It is evident that the number of wires passing through all the stations will be two more than the number of stations, irrespective of that number.

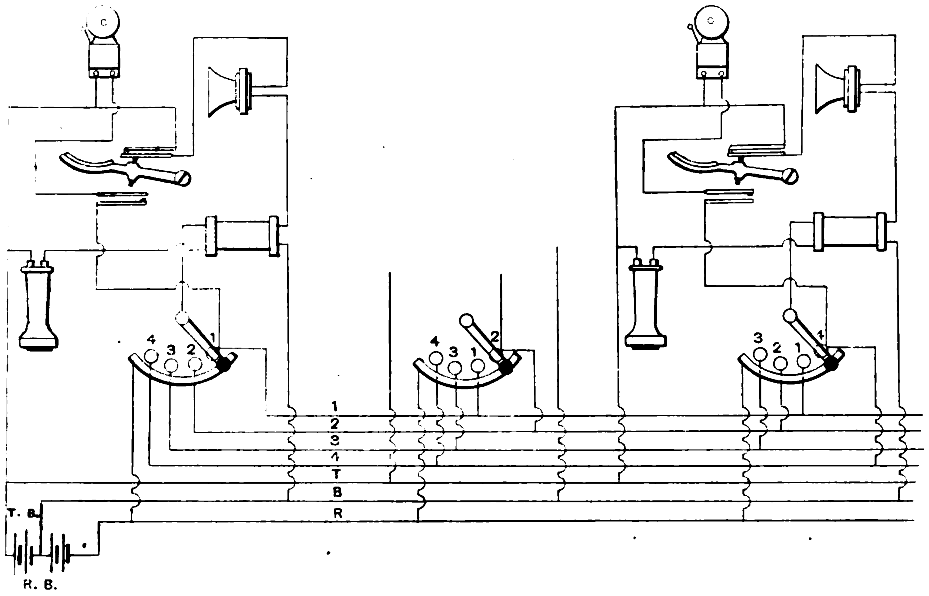

FIG. 32.—SYSTEM HAVING COMMON TALKING AND SIGNALLING BATTERY.

If Station 4 desires to call up Station 1 for example, No. 4 will turn his switch lever until it rests upon button 1, then a slight pressure upon the switch knob causes the switch lever, S, to touch the contact strip, D, completing a circuit from the battery, CB, to contact strip, D, lever, S, and button, 1, at Station 4; line wire, 1, wire, d, switch, H, and bell, C, at Station 1, and back to the battery through the common talking wire. When both subscribers remove their receivers from the hooks, the circuits are completed over line wire 1 with the common talking wire as a return. At the close of the conversation the receiver is simply hung upon the hook and the automatic mechanical device returns the lever to the home position.

Fig. 30 represents an automatic magneto-call telephone for which the diagram of connections is shown in Fig. 31. This form is preferable where the stations are widely separated or where the lines run outside to connect different buildings. The switch, transmitter and bell are all mounted upon the door of the box containing the generator. In all forms of the instrument the hook and switch are mounted as shown in this figure upon the door of the box. Fig. 31 shows the application of the Ness automatic switch to an intercommunicating system using magneto-generators and polarized bells. The number of wires passing through all the stations will in any size of system be one in excess of the number of stations.

Fig. 32 shows the application of the Ness automatic switch to an intercommunicating system using one common and centrally located battery for supplying both the ringing and talking current. The section, TB, of the battery supplies all the microphone transmitter circuits and the whole battery, RB, supplies the current for ringing the ordinary vibrating bells that are used in this system. In this arrangement it is evident that the number of wires passing through all the stations will in any size of system be three in excess of the number of stations.

There are many places, such as hotels, schools, and some factories, where all that is required is that one central station be able to call up any one of the other stations, and vice versa, but where the different stations are not required to call up one another. One automatic switch at the central station is, in such cases, all that is required. The diagram of connections for such a system, employing the Ness automatic switch at Station No. 1 only, is shown in Fig. 33. The number of wires passing through all the stations will in any size of system be one in excess of the number of stations.

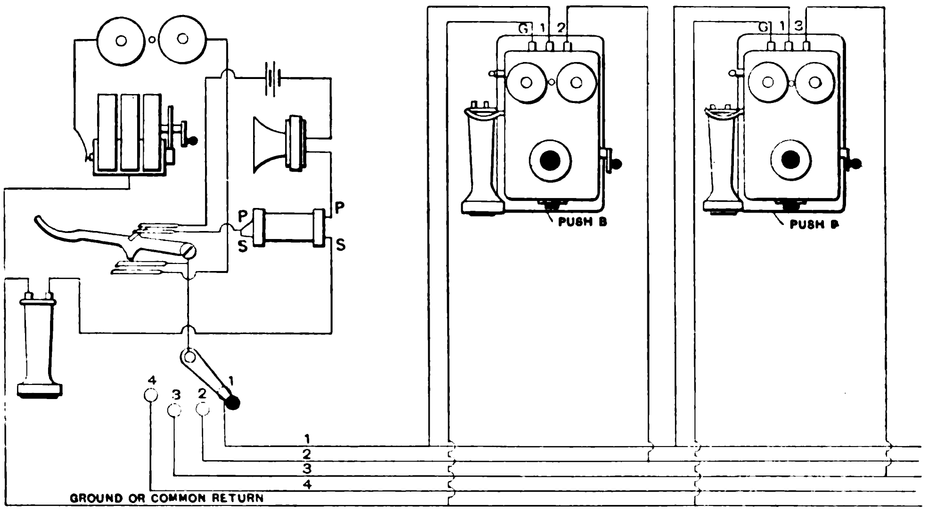

FIG. 33.—RADIAL SYSTEM WITH AUTOMATIC SWITCH.

THE ELECTROLYTIC PRODUCTION OF SODA AND CHLORINE.

BY JAMES F. HOBART.

Having explained the principle of soda and chlorine production and discussed the various forms of apparatus that may be used therefor, it only remains to describe the installation of a plant in actual practice. I know of no better system and apparatus at present than the Mercer, illustrated in the accompanying engravings.

The Mercer cells, shown by Fig. 1, consist of earthenware crocks about 18 ins. in diameter and of practically the same height, not counting the cover, water seal and other accessories. The total height of the cell is about 3 ft. These porous crocks form the diaphragms of double-fluid cells and are the containing vessels for the salt solution and chlorine.

A thickness of asbestos paper is wrapped around the crock, then a perforated iron strip about 12 ins. wide is wrapped around outside of the paper, and secured by iron clamp bands. The sheet iron strip forms the negative element or cathode. The crock, with its sheath of iron, is set up in an iron (or galvanized iron) tank, which forms the outer containing vessel in which the caustic soda is deposited. The outer tank contains five cells, as shown by Figs. 2 and 3.

The anode, or positive plate, consists of a mass of carbon to which is cast a lead lug for connection purposes. This element is suspended inside the cell from the center of the cover as shown in Fig. 1, and the horizontal part contains openings for the upward egress of the chlorine gas. A water seal forms a simple and complete closure of the cell against the escape of gas save by the pipe provided for that purpose. At the right of the cell is shown (in section) a cup-like projection with a conduit leading nearly to the bottom of the cell. This is for the purpose of introducing the charge of chloride of sodium solution which must not be raised above the dotted line shown across the broken-away portion of the cell. The fluid in the containing tank is always kept at a little higher level than the cell solution. This serves to prevent the escape of salts above the water line, or a "sneaking" of the inner solution whenever the current may chance to be off for a short time.

The tanks, as indicated in Fig. 3, are placed upon brick piers, with two thicknesses of insulating material beneath each; one thickness is of wood and the other of some vitrified substance. If desired, the insulation beneath the iron tanks may be omitted, the apparatus then being operated as a grounded system; in this case only the wires to the carbons—the positive—are insulated. However, it is better to insulate the cathodes.

Between the two lines of tanks is placed a 3-inch tile pipe for leading away the chlorine gas; connection between each cell and the tile pipe is provided in the shape of a short lead pipe from each cover. The positive wires are supported in grooves in the sides of the same timber which carries the gas pipe, which the writer does not regard as good practice. It is better to support the wires upon good porcelain insulators at short intervals.

Fig. 2 shows a plan view of a small plant of 40 cells, as arranged in a manufacturing plant in Massachusetts. This was merely an experimental plant, and is now being replaced by a large installation consisting of several hundred cells, supplied with current by a direct-connected generator and engine. The five cells or positive elements in each single tank or negative element are connected up in parallel, of course, and the 5-cell tanks are connected in series. As here arranged, these tanks are 10 ft. long, and when placed side by side with the gas and electrical conduits between, occupy a floor space 5 ft. wide. There is also a 5-in. space between the ends of the iron tanks.

The height of each iron tank is 18 ins., and each tank is mounted a little lower than the preceding one in the series. The difference in elevation between two neighboring tanks is 5 ins. All that is required is to have each one high enough so that the overflow can fall from the drip pipe into the following tank. A peculiar feature in connection with this system of distribution is that the overflow from one tank should flow to the next tank in drops, not in a stream, as in that case a passage through the liquid would be provided for the current, shunting the path through the cells. There is no chance for a reversal of current and the consequent destruction of the iron cathode and the defilement of the ions. Should the overflow begin to stream a mere cutting out of a group of five cells takes place and continues as long as the stream remains. When it ceases, the proper distribution of current at once recommences without any attention whatever.

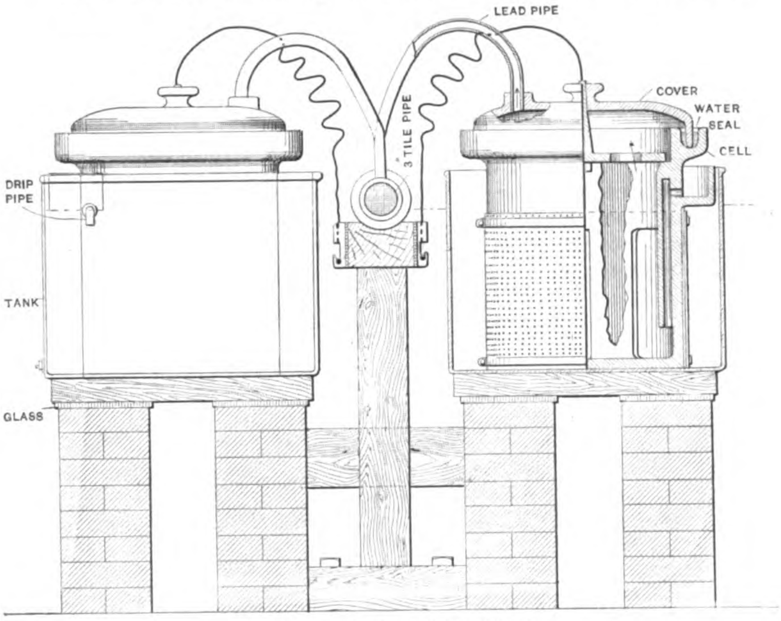

FIG. 1.—ELECTROLYTIC CELLS

An impressed e.m.f. of about five volts per cell is found necessary for the proper operation of the system. This calls for an impressed e.m.f. of five volts for each tank, or 40 volts for the system illustrated About 144 amperes per cell is required to properly work the anode surface presented in these cells, and that means 720 amperes for the group of five cells. Thus, nearly one horse-power per cell is required or a total of 40 horse-power in the entire plant. There is also some power necessary for the necessary pumping and distribution of the gas and caustic potash for the purpose of making "bleach," as the liquid resulting from the mixture of chlorine gas and the lime water is called.

The process of preparing the bleaching solution after the chlorine has been evolved is not a continuous one, as the apparatus illustrated is arranged. There are two mixing tanks, in one of which the solution is being prepared while solution is being drawn from the other tank. The vertical arrangement of the apparatus is shown by Fig. 3, from which the nearest mixing tank has been omitted, showing the cooling apparatus, the tower and one of the mixing tanks. This engraving also shows the arrangement of the several cathode tanks, the drips from the several tanks, and the arrangement of the circulating pumps.

The gas pipe is turned upward and enters a box fitted with either diaphragms to compel the circulation of the gas, or with a system of return pipes through which the gas passes back and forth, as in a chamber surrounded by water which cools the gas to the desired temperature. Then the gas passes into the bottom of a closed tank in which a partial vacuum is maintained by means of a steam ejector at the top of the tank. A quantity of water is put in the mixing tank, and by means of the centrifugal pump shown at the right of the engraving, the water is forced to the top of the 9-foot tower, through which it percolates through suitable perforated baffle plates so arranged as to break up the water into small streams or drops, thus exposing a great surface of liquid to action of the chlorine gas which is absorbed very readily by water, as described in previous articles. After the water passes through the diaphragms and water to the bottom of the tower, it is led again to the mixing tank, from which the pump is constantly removing a portion of it and sending it again and again to the tower to absorb more chlorine. Thus each tankful of water must be passed through the tower over and over until the bleach liquid has become of the desired strength, when the valves may be closed and the operation transferred to the other tank.

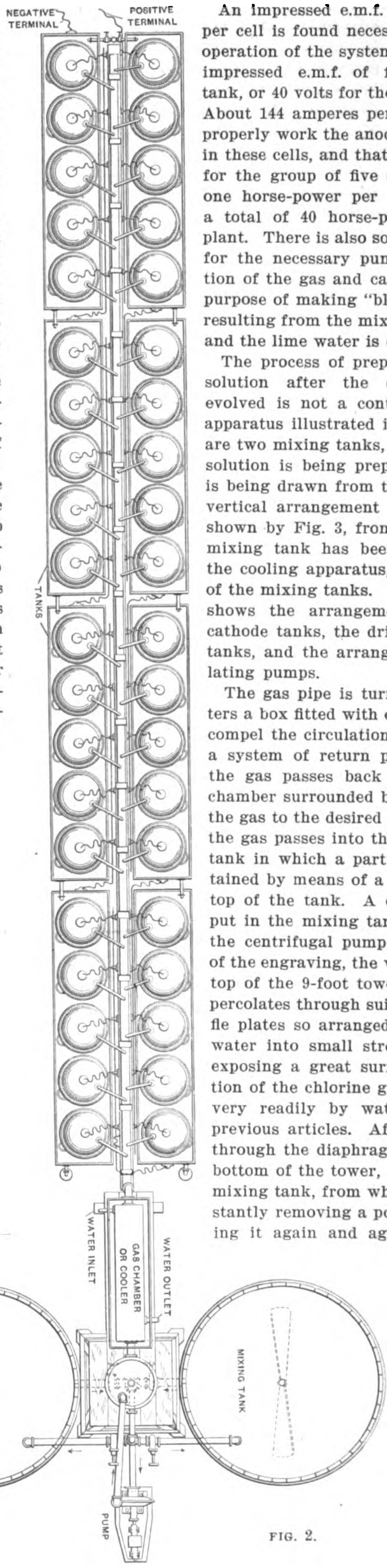

FIG. 2.

The chlorine-making process is thus a continuous one, proceeding without interruptions as long as current is kept on and a supply of salt solution exists in the cells. The bleaching may readily be made a continuous process if necessary.

While the above described operations have been going on, there has been another action of which nothing has been said. At the extreme left of Figs. 2 and 3 may be seen a small pipe which extends into the first tank of each series. Through these pipes water is admitted to the cathode tanks drop by drop. The soda evolved at the cathode enters into solution with the water thus provided, and forms one of the electrolyte liquids. As the water drips from tank to tank, the percentage of soda increases, until at the far end of the plant the resulting caustic solution is carried off by pipes, at a strength depending upon the amount of water admitted at the first tank.

The plant here described was not fitted with a generator best adapted to the purpose. Instead of 40 volts and 720 amperes the generator used gave 94 volts and an average amperage of 600. During a 23-hour test run, January 24 and 25, 1899, the following results were obtained:

Average ampere-hours, 138.

Available chlorine liberated, 563 lbs.

Available caustic potash liberated, 630 lbs.

Percentage of chlorine equal to 1689 lbs. of 35 per cent bleaching powder, or about 21 lbs. per cell in 23 hours.

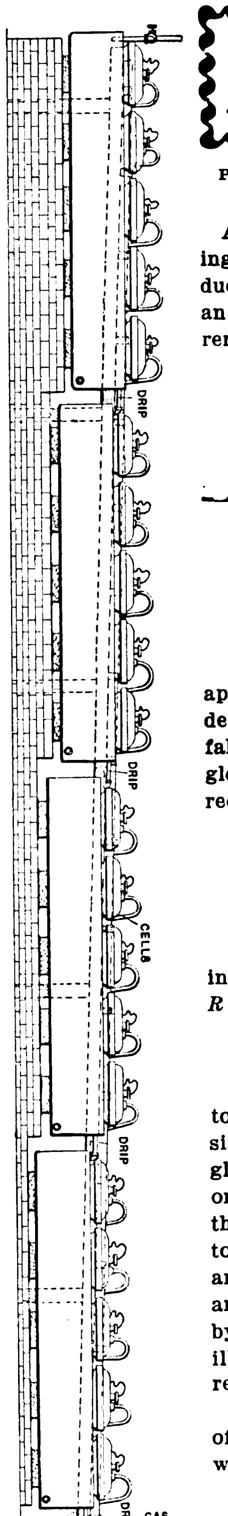
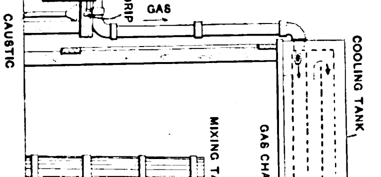
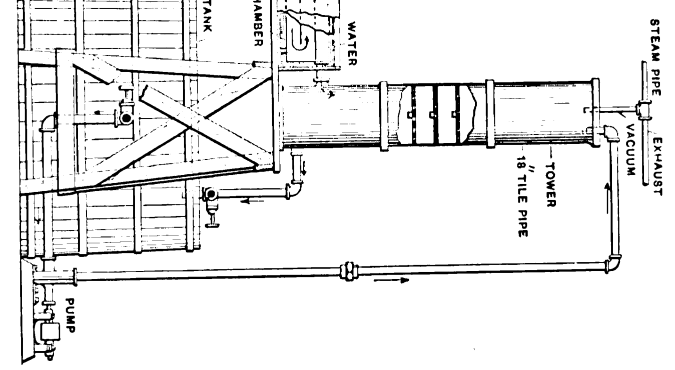

FIG. 3.—ELEVATION OF ONE SIDE OF AN EIGHT-TANK PLANT.

Lessons in Practical Electricity

PHASE DISPLACEMENT IN A SECONDARY CIRCUIT.

As explained in previous lessons, passing an alternating current through an inductive device, such as a coil wound about an iron core, results in causing the current to fall out of phase with the e.m.f. applied to the terminals of the inductive device. The amount by which the current falls behind the e.m.f. is termed the "angle of lag," and this is determined indirectly by either of the formulas:

$$\frac{X}{R} = \tan \phi \ldots\ldots\ldots\ldots\ldots\ldots\ldots(11)$$

$$\frac{E}{V} = \text{secant } \phi \ldots\ldots\ldots\ldots\ldots(12)$$

in which X is the reactance of the load; R is its resistance; E is the e.m.f. applied to its terminals; V is the drop due to resistance alone ($C \times R$), and ϕ is the "angle of lag." Which of these two formulas one shall use depends, of course, upon the data available; sometimes it is easier to ascertain the reactance and resistance, and in other cases the impressed e.m.f. and the resistance drop can be obtained by simple measurements. For the present illustration it will be assumed that the reactance and resistance are known.

In the case assumed for the illustration of the last lesson the transformer current was 60 amperes in the secondary, and the secondary e.m.f. delivered to the load was 95 volts. This would give the load a resistance of 1.5833 ohms. Changing this load into an inductive load having a resistance of, say, 1.4 ohms, and a reactance of 0.8 ohms, the tangent of the angle of lag, according to formula (11), will be

$$\frac{0.8}{1.4} = .57143$$

and a table of tangents shows the angle to be 29¾°.

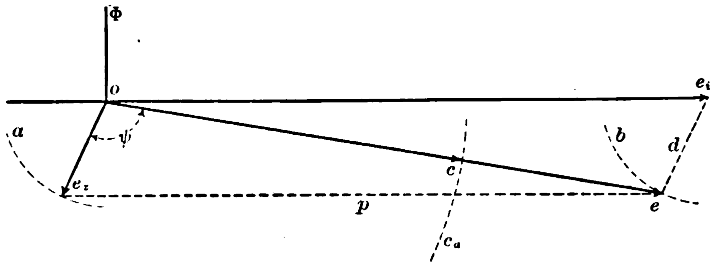

FIG. 31.

The impedance of the load circuit will be $Z = \sqrt{R^2 + X^2} = \sqrt{.8^2 + 1.4^2} = 1.6125$ ohms, and the e.m.f. necessary to drive 60 amperes (the secondary current) through this impedance will be 1.6125 × 60 = 96¾ volts. This gives the length of the secondary e.m.f. vector, e, for the new conditions; its position or phase relation is easily plotted. Having assumed the same secondary current as before—60 amperes—the current vector, c, Fig. 31, remains the same length, but is 29¾° behind the e.m.f., e. Now, no matter what the phase of the current, c, is, the reactance e.m.f., e_x, Fig. 32, due to magnetic leakage, is always 90° behind it; furthermore, the conditions within the transformer being unchanged, the impedance e.m.f., e_z, Fig. 32, maintains the same relation to the reactance e.m.f., e_z, consequently to the current, c, as before the character of the load changed; the angle, ψ, therefore, remains constant. Therefore, if the current vector be rotated so as to describe the arc, c_a, Fig. 31, the vector, e_z, indicating impedance e.m.f., will describe the arc, a.

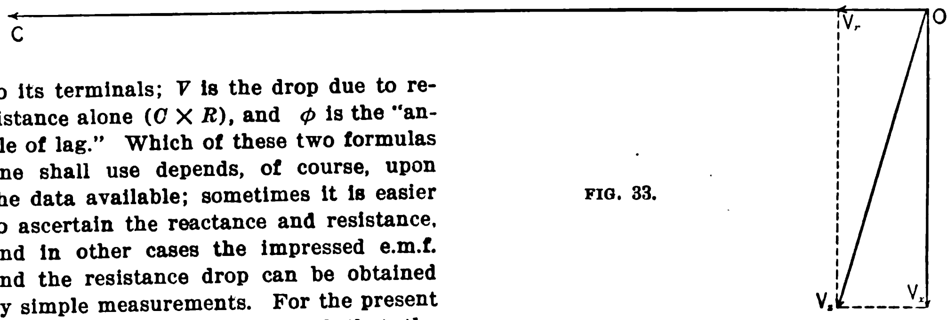

FIG. 33.

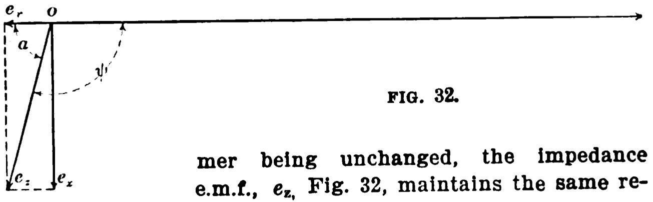

FIG. 32.

In plotting a parallelogram for the combination of two forces, one must duplicate the two lines representing the forces to be combined; thus, in Fig. 31, the dotted line, p, is a duplicate of the induced e.m.f.

line, e_1 and the line, *d*, is a duplicate of e_s. Consequently, if e^s is rotated about its origin, *d* must likewise rotate, describing the arc, *b*. Having laid down this arc

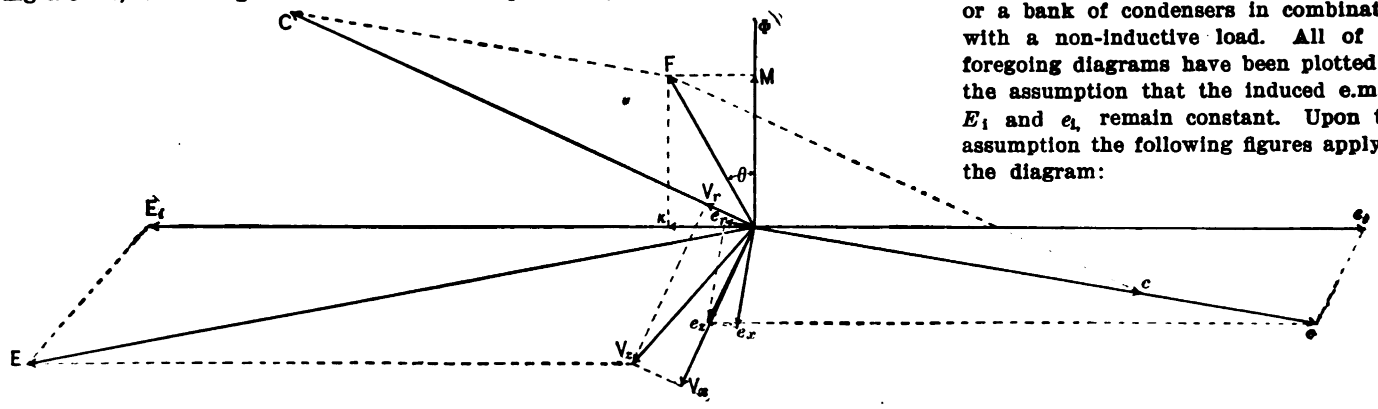

FIG. 30.—TRANSFORMER DIAGRAM, WITH SECONDARY CURRENT AND DELIVERED E.M.F. IN PHASE.

as representing a path at some point of which the end of *d* must lie, it only remains to find the point along that path which will be the proper distance from the origin of all the vectors to represent the 96¾ volts secondary e.m.f., *e*, delivered to the load; this will be also the point to which *d* must be drawn. Then plotting the current, *c*, 29¾° behind this will place the vector, e_s, parallel with the line, *d*, drawn from the end of *e* to the end e_1 and complete the parallelogram of secondary e.m.fs.

The primary current will also have changed its phase relation, because the

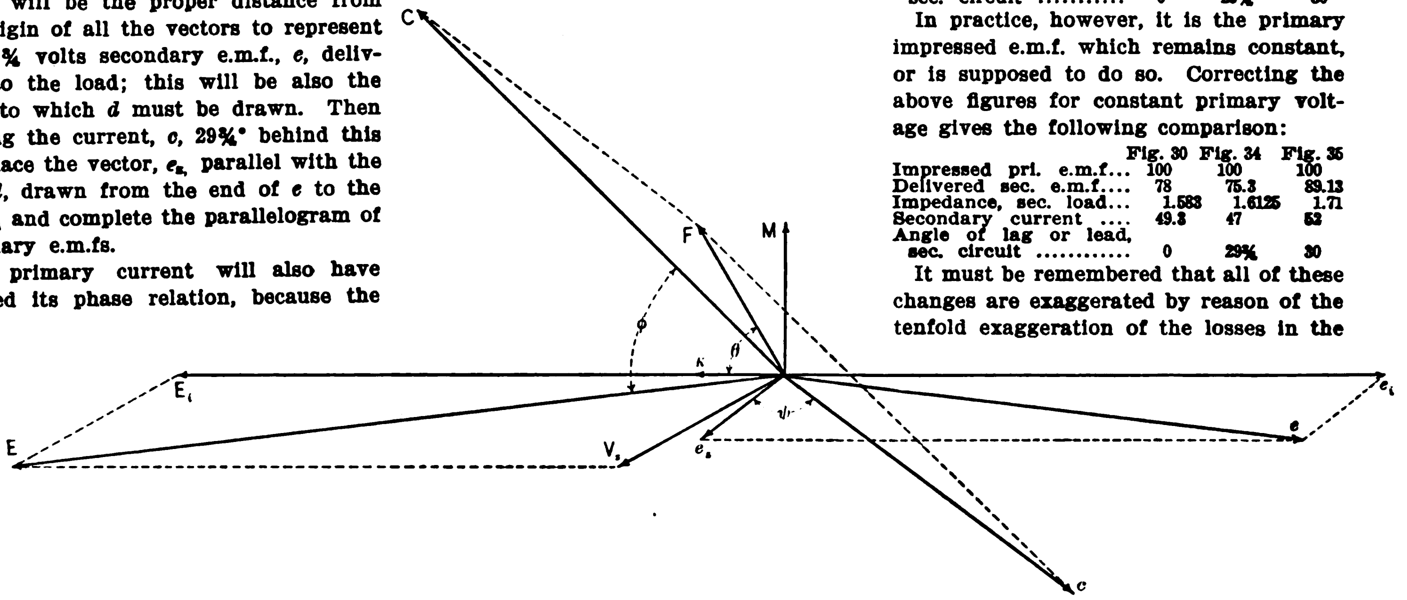

FIG. 33.—DIAGRAM SHOWING THE RESULT OF 30° LAG IN SECONDARY WORK CIRCUIT.

combination of the primary current with the secondary current produces the field, *F*, Fig. 30, which we are assuming remains fixed. The phase relations between the primary current, *C*, and the reactance and impedance e.m.f. vectors, V_x and V_z, Fig. 33, remain fixed, just as in the case of the

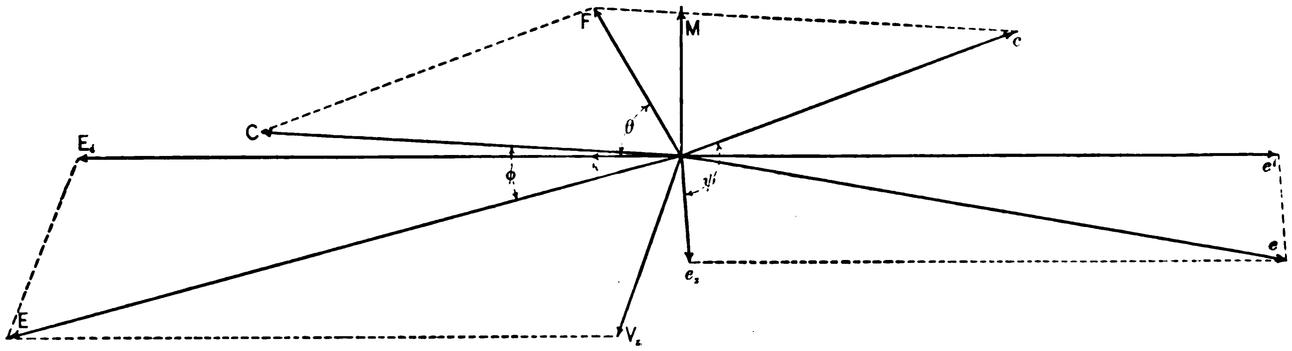

FIG. 34.—DIAGRAM SHOWING THE RESULT OF 30°. LEAD IN SECONDARY WORK CIRCUIT.

secondary, no matter where the phases go so long as the constructional characteristics of the transformer are unchanged. The resistance, reactance and impedance "drops" are plotted backward because in the primary it is the e.m.f. required to overcome resistance and reactance, and consequently impedance, that is to be considered, as this adds to the required impressed e.m.f.; whereas in the secondary we are dealing with generated e.m.f. and desire to know the amount by which this is decreased by the counter e.m.fs. of resistance and reactance, and therefore impedance.

In Fig. 34 the results above obtained are plotted together with the consequent conditions in the primary. It will be noticed that the inductive secondary load has greatly increased the lag of the primary current, *C*, behind the primary impressed e.m.f., *E*; this angle is indicated here by *φ*. Fig. 35 shows the result of changing the secondary circuit to one having negative reactance, or condensance, such as a synchronous motor overexcited, or a bank of condensers in combination with a non-inductive load. All of the foregoing diagrams have been plotted on the assumption that the induced e.m.fs., E_1 and e_1, remain constant. Upon this assumption the following figures apply to the diagram:

	Fig. 30	Fig. 34	Fig. 35
Impressed pri. e.m.f...	122	128½	115½
Delivered sec. e.m.f....	95	96¾	102½
Secondary current	60	60	60
Angle of lag or lead, sec. circuit	0	29¾	30

In practice, however, it is the primary impressed e.m.f. which remains constant, or is supposed to do so. Correcting the above figures for constant primary voltage gives the following comparison:

	Fig. 30	Fig. 34	Fig. 35
Impressed pri. e.m.f...	100	100	100
Delivered sec. e.m.f....	78	75.3	89.13
Impedance, sec. load...	1.583	1.6125	1.71
Secondary current	49.3	47	52
Angle of lag or lead, sec. circuit	0	29¾	30

It must be remembered that all of these changes are exaggerated by reason of the tenfold exaggeration of the losses in the transformer, which was explained in the previous lesson. It will be evident, however, that in practice the effect of introducing inductance or condensance in the secondary circuit is the same in kind as shown by the diagrams, the difference being only in the degree or extent of the various effects. These effects are, for inductive secondary load, a decrease in the secondary delivered e.m.f., and an increase in the lag of the primary current behind its e.m.f.; for condensive load, the opposite effects.

Letters on Practical Subjects

A Peculiar Arc-Light Problem.

To the Editor, American Electrician;

Sir:—We have a series of 9.6-ampere open-arc lamps divided into four circuits and supplied from a single No. 9 Brush arc machine. A few nights ago two-thirds of the lamps ceased to burn and the other third, scattered around in various parts of the circuit, continued to burn as brightly as ever. Short-circuiting the various loops of the total series one by one had apparently no effect upon the lamps in the remaining loops. The machine ran steadily and the ammeter showed 9.6 amperes throughout. Substituting another machine also made no change in the conditions. It was finally found that the wire of one of the loops had parted in the center of a span across the river and the ends had fallen into the water. I would be glad if some of your readers would offer suggestions as to why about one-third of the total number of lamps continued to burn and two-thirds, scattered around on different parts of the circuit, went out.

Huntingdon, Pa. D. E. Carpenter.

Irregular Indicator Diagrams.

To the Editor, American Electrician;

Sir:—I enclose three indicator diagrams of recent date, two of which were taken from engines of the same size; these engines are numbered 4 and 5, and the diagrams are marked with the engine numbers. Both of these diagrams were taken with the same indicator and reducing motion, and I am at a loss to know why diagram from No. 4 engine is so much shorter than that from No. 5. I would like to have some of your readers suggest an explanation of this, and also of the wavy compression line, which is worst in the diagram from engine No. 6, but which appears to some extent in both of the other diagrams also. L. S. C.

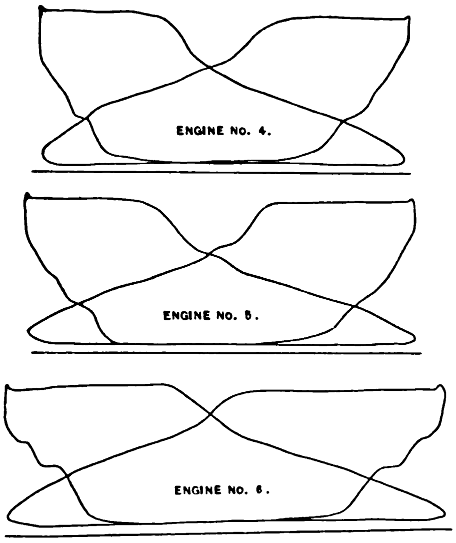

FIG. 1.—IRREGULAR STEAM ENGINE INDICATOR DIAGRAMS.

Lawrence, Mass.

Setting Dynamo Brushes.

To the Editor, American Electrician;

Sir:—We are operating four 150-kw. 110-volt multipolar generators which in the beginning had the brushes set in the usual way—i.e., with alternate rows of brushes set to the outer end of the commutator and the intermediate rows toward the inner end, as shown in Fig. 1, so that the whole surface of the commutator would be covered. I found that invariably on all of the machines the positive brushes would furrow the commutator, leaving slight ridges between them, which, of course, interfered with the negative brushes, and no amount of adjustment would obviate this trouble. I finally tried setting the brushes as shown in Fig. 2, that is, with two rows set to the outer end of the commutator, the next two to the inner end, and so on all the way around. This arrangement entirely eliminated the ridging of the commutator and caused it to run smooth.

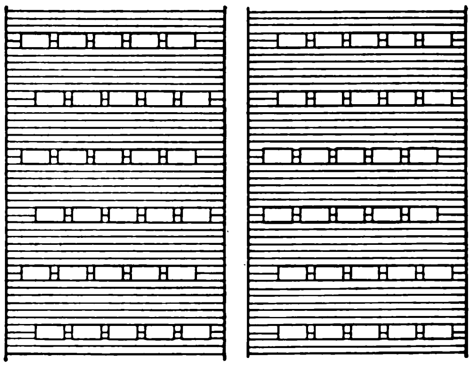

FIG. 2.—SETTING DYNAMO BRUSHES.

Los Angeles, Cal. B. F. Knau.

Some Practical Kinks.

To the Editor, American Electrician;

Sir:—Recently we met with a peculiar case, causing a considerable delay in car service. The power-house circuit-breakers would not stay in; and as the line sections were not controllable from the power house we at once began to remove the jumpers at the different trolley-wire section-insulators. After a few trials, the faulty section was located, and service resumed on the remaining sections. The cause of the trouble was found in one of the cars; it happened thus:

Several days before the car had been brought in with its vestibule badly jammed in and its platform sills shoved back a number of inches. Besides other damage a cross sill was badly cracked. Bolts drew this together, and a large washer of dash iron was put inside the car, back of the door and under the seat. Here was a loose wire, tapped to the car circuit between the trolley and the first hood switch. It was once used for a lightning arrester tap, but a later style of arrester rendered it useless, so the wire was coiled up with its end taped. The carpenter had accidentally got part of this wire under the washer, which now had cut through the insulation, while the washer touched a truss-rod. This in turn completed the ground from the truss-rod plate at the end of the car sill to the dash, while the brake-rod and chain did the rest. We cut off the wire higher up and taped the free end, replaced the section jumper, and all was well once more.

A good thing for street car jacks having small bases, either round or rectangular, is a piece of boiler iron, 12 ins. x 18 ins., fastened to the base. The constant annoyance of tilting will then be completely obviated.

Wishing to do some babbitting one day, and having no putty nor clay about the place, we made a dough of flour and water. The result was both satisfactory and surprising. It has the great advantage of not softening or giving way, as putty will do, for it bakes itself hard where placed, holding the babbitt securely. We have never heard of this being used before.

W. B. Arthur.

Niagara Falls, N. Y.

Electric Bells on 110-Volt Circuits.

To the Editor, American Electrician;

Sir:—I take the liberty of submitting herewith a plan for operating electric bells from lighting or power circuits, which will be found convenient in a great many instances. The plan consists simply of connecting up a number of incandescent lamps in series across the lighting or power mains and connecting the bell circuit in parallel with one of the lamps. In remote localities, where electric service is to be had but where there are no facilities for replacing worn-out batteries, this plan may be used to good advantage.

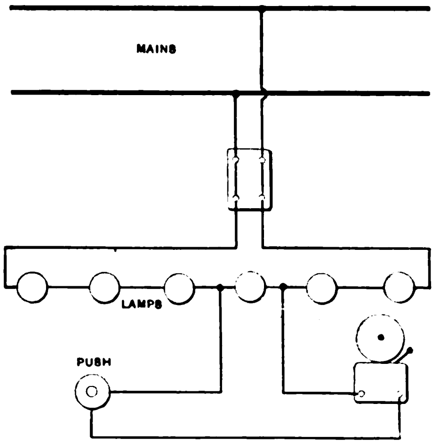

FIG. 3.—METHOD OF OPERATING ELECTRIC BELLS FROM A LIGHTING CIRCUIT.

Edward R. Avery.

Bannack, Mont.

Electrical Catechism

538. What is the relation between electricity and heat?

Since both are forms of energy, one may be changed into the other. It is easy to change electrical energy into heat energy with perfect efficiency; that is, the heat developed being equal to the electrical energy transformed. It is not so easy to change heat energy into electrical energy, the processes being apparently more complicated and being less efficient. It is practicable to change 1000 watts of heat energy into an equal amount of heat energy, but 1000 watts of heat energy cannot be changed into 1000 watts of electrical energy by any process yet developed.

539. How can heat energy be changed into electrical energy?

The most familiar method is to apply the heat to a steam boiler and drive an engine and dynamo. A good boiler will transfer to the water and steam about 80 per cent of the energy in the fuel; a good steam engine will change from 10 to 20 per cent of the total energy of the steam into mechanical energy; a good dynamo will change from 80 to 95 per cent of the mechanical energy received into electrical energy available for use. Putting these together gives an efficiency of from 6 to 15 per cent of the heat energy available as electrical energy, the rest being untransformed heat energy. By the use of gas generators and gas engines driving dynamos, a somewhat higher efficiency may be obtained. An efficiency of nearly 50 per cent is claimed for certain forms of gas battery in which the energy in the gas is changed into electrical energy through chemical action, but such devices have not been reduced to a commercial basis. By the thermopile a theoretical efficiency of about 12 per cent is possible, although about 3 per cent is the highest efficiency actually obtained.

540. What is meant by a thermo-couple?

A thermo-couple is an electric circuit containing conductors of two different materials which will cause a thermo-electric current when their two junctions are at different temperatures. A common case is that of a circuit made up partly of iron wire and partly of copper or of German silver. In fact, thermo-electromotive forces are set up in any circuit in which there is any lack of uniformity of material and temperature. A circuit made up partly of hard copper wire and partly of the same wire that has been softened by annealing will have thermo-electric currents set up if the wire is heated at the point where the hard wire joins the soft wire. The amount of the current is governed of course by Ohm's law, and the e.m.f. depends upon the difference of temperature and also upon the materials. When large thermo-electric currents are desired, the different materials should be chosen with great care. Much experimenting has been done to discover the combinations that give the best results, and special alloys are used by manufacturers of thermopiles. Iron and German silver are frequently used for experimental work, since they are easily obtained and also give comparatively high e.m.f. Thermo-electric currents were first observed by Johann Seebeck, a German physicist, in 1821.

541. Are thermo-electric currents common?

They are more common than is often suspected. They often make trouble with accurate electrical measurements, since it is frequently impossible to keep all parts of the apparatus at the same temperature; thermal currents are thus set up which interfere with exact measurements. For example, in measuring resistance with the Wheatstone bridge, the currents heat the circuits slightly and this inequality of temperature sets up thermal currents which affect the galvanometer after the main current has been cut off, so that it is difficult to obtain an exact balance. Thermal currents are always of low electromotive force, being less than one-thousandth of a volt per junction, so that they are troublesome only in circuits of small resistance and with delicate instruments. It is suspected that electrolytic troubles are sometimes started by thermo-electric currents, although this seems not to have been verified.

542. What is a thermopile?

The thermopile is an apparatus for transforming heat energy into electrical energy. It is the thermo-couple developed by making a circuit of a number of pairs of metals or alloys so arranged that alternate junctions may be heated while the remaining junctions are kept at a lower temperature. If the two conductors are iron and German silver, the heat causes current to flow from the German silver to the iron at the hot junctions. Such currents are called "thermo-electric." The heat is generally supplied by one or more gas jets, although the largest sizes are made like stoves and are suitable for burning coal. The outer junctions are usually kept comparatively cool by means of extended plates, sometimes formed into tubes so as to assist the circulation of cooling air; in the Cox thermopile, which probably represents the highest development, the outer ends are cooled by the circulation of water in the jacket.

543. For what purposes are thermopiles used?

They are used for obtaining currents where great steadiness is required, such as in chemical analysis. They are suitable for all purposes for which a closed circuit battery would be used; that is, when currents of uniform strength are desired for long periods. They are suitable for electro-plating, for operating telegraph lines, small motors for fans or other purposes. Current from a thermopile is generally cheaper and less troublesome than that obtained from a primary battery. Thermopiles are also used for measuring radiant energy and for measuring temperatures.

544. Are thermopiles suitable for electric lighting?

They have not been constructed in sufficiently large sizes, except for small lamps and they cannot compete with engines and dynamos, both because of difficulty of making large sizes and because of the greater efficiency of the engine and dynamo.

545. How is a thermopile used for measuring radiant energy?

Thermopiles for such work are arranged in rectangular form somewhat as shown in the figure. When one end is exposed to any radiation, such as the sunlight or the heat radiated from a fire or lamp, that end absorbs heat and becomes warmer than the other end, the result being a thermo-electromotive force. If the wires leading from the thermopile are attached to a galvanometer, the e.m.f. and current can be measured. By comparing the amount of thermal current obtained when the end of the thermopile is directed successively toward different sources of energy, the relative intensities of their radiations are indicated by the current through the galvanometer.

546. How is a thermopile used for measuring temperature?

Such use depends upon the fact that, within certain limits, the current in a thermal couple varies directly with the difference between the temperatures of the hot and cold junctions. After the apparatus has been properly calibrated by keeping one junction at a fixed temperature while that of the other is heated to different known temperatures, the current produced being carefully noted at each step, the apparatus can be used to determine the temperature of any desired spot by placing one junction at that spot while the other is kept at a standard or known temperature. The temperature at the spot desired can then be calculated from the current through the thermo-electric circuit. A modification is sometimes used when it is desired to keep two points at equal temperature: junctions of a thermal couple are placed one at each of two points, and if no current flows through the circuit, it indicates that the two junctions are at the same temperature.

547. Is the thermo-electric effect reversible?

Peltier discovered in 1834 that a current through a junction of two metals would heat or cool it according to the direction of the current, heating being observed if the direction of the current was the same as that which would have been produced by cooling the junction, and the reverse. This "Peltier effect" acts something like a counter-electromotive force in the thermopile. Various attempts have been made to utilize the Peltier effect for artificial refrigeration, but such seem not to be commercially successful.

Queries and Answers

IMPORTANT.—No attention will be given to inquiries which do not give the full name and address of the inquirer.

What is meant by the calorific value of fuel? T. H. C.

The number of heat units liberated by the combustion, or burning, of one pound of the fuel.

How much and what size resistance wire is needed for the shut-field circuit of the Brocksmith machine described in the March issue? H. C. S.

About 1000 ft. of 18 per cent German silver wire, No. 17 B. & S. gauge.

I am operating a 15-kw. Edison shunt-wound 125-volt dynamo in parallel with a 25-kw. compound-wound Card dynamo, and the two machines divide the load fairly well. Can I run the same machines on the two sides of a three-wire system so that each will carry the proper proportion of the load? B. T. R.

Yes; but your system will not operate at good economy because 10 kilowatts of your load will be carried by the neutral wire if each machine is fully loaded.

About what is the mechanical efficiency of an ordinary steam engine, and how are the friction losses divided? J. W. K.

About 80 to 90 per cent, depending entirely upon the size and class of the engine. In high-speed horizontal engines about 45 per cent of the friction loss is in the main bearings; about 33 per cent in the piston and rod; about 8 per cent at the crank pin, 6 per cent at the crosshead and wrist pin, and 8 per cent in the valve gear. This varies, of course, with different types of engines.

What is the general rule for obtaining the pitch of armatures having an odd number of coils? R. R. G.

Add to or subtract from the actual number of coils a number sufficient to make the result an exact multiple of the number of magnet poles; divide this by the number of pairs of poles and the result will be the average pitch. If C = number of coils; x = number by which the coils exceed or fall short of some multiple of the magnet poles; y = pitch, and P = pairs of poles, then

$$\frac{C \mp x}{P} = y.$$

Is it customary to use 1100-volt transformers on 1000-volt circuits and the contrary? It does not seem that a transformer wound for one voltage could give proper results on a different voltage. G. C. F.

Yes; the only differences in the working of the transformer are that when the voltage is slightly higher than its rated e.m.f. the core loss is greater and the regulation is better; if it is used on a circuit the voltage of which is slightly lower than its rated e.m.f., the core loss is less, but the regulation is not so good. The differences are not sufficiently great to justify building transformers for two voltages as near each other as 1000 and 1100.

What is the most economical point of cut-off for a single-cylinder engine running at 80 lbs. boiler pressure? Also for a compound engine running at 120 lbs. boiler pressure, and a triple expansion engine running with 160 lbs. boiler pressure? All of the engines are run condensing. J. B.

It is not practicable to specify rigidly the most efficient cut-off without knowing more about the engine. As a general thing the most economical cut-off for a simple engine is in the neighborhood of ¼ stroke. The economical cut-off for the high-pressure cylinder of a compound or triple-expansion engine is somewhere near ⅓ stroke, but this depends upon the ratio of the cylinder diameters.

What does hunting or pumping in a rotary converter mean? W. D. T.

When two or more rotary converters, or other alternating-current machines, are operated in parallel the slightest speed variation in one of them causes the other one to be dragged back or forth as the case may be in an effort to restore synchronism, and it will go a little too far and then come back and so on, oscillating from a point a trifle above synchronism to a point a trifle below synchronism. This is called pumping or hunting. It is not perceptible mechanically, of course, as it consists of minute variations in speed which are not apparent except by the interchange of so-called wattless currents between the two machines.

How can I adjust a 25-kw. and a 50-kw. machine so that they will run in parallel and divide the load properly at different loads? M. S. P.

Put the machines in circuit under full load and adjust the rheostats until they divide the load properly and the e.m.f. is right at the center of distribution. Then measure the e.m.f. at the switchboard bus-bars; call this *E*. Next run the 50-kw. machine without any load and adjust the rheostat until the e.m.f. of the machine is the rated e.m.f. of the lamps. Then load the machine up to its full capacity without touching the rheostat handle, and adjust the shunt on the series winding until the bus-bar e.m.f. is equal to *E*, previously obtained. Do the same with the 25-kw. machine, and the two will run properly together.

What is the leakage coefficient of a dynamo or motor? How does it affect the efficiency of the machine? F. M. D.

The leakage coefficient is the number by which the magnetic flux actually entering the armature at any one magnet pole must be multiplied in order to ascertain how much magnetic flux passes through the core of the magnet within the coil. For example, if there are 1,000,000 lines of force entering the armature under a north pole and 1,200,000 lines of force are passing through the magnet core inside of the field coil, then the leakage coefficient is 1.2, which means that .2 or 20 per cent of the total lines of force generated by the magnet coil do not enter the armature core at all, but leak from one pole-tip to another and from the pole-tips to other parts of the frame. The effect upon the efficiency of the machine is to decrease it slightly, as more exciting current is required to maintain the field than would be needed if all of the lines of force went through the armature. The efficiency is affected very little, however.

Is there any other way than the usual multiple-series method of connecting up 110-volt lamps on a 550-volt circuit so that the lamps can be turned on and off in groups of five? (2). How can the horse-power of a small motor be determined? (3). What would happen if a shunt-wound dynamo were short-circuited across its terminals while running under full load? W. E. H.

Not without using dead resistances. (2). If the motor is shunt wound run it without load and measure the current passing through the armature. Deduct this from the rated full-load armature current of the machine and call the result the "work current." Next block the armature so that it cannot turn, and connect it up to the circuit in series with an adjustable resistance. Adjust this resistance until the current flowing through the armature is equal to the "work current" previously obtained. Then measure the voltage at the terminals of the resistance, multiply this by the "work current," and you have the work done by the motor in watts. (3). If the machine is a small one, short-circuiting it will kill the field without damage to the machine other than a vicious sparking at the brushes for a few seconds. If the machine is large, however, the field magnetism will not die rapidly enough to avoid damaging the armature by the heavy overload current flowing through the short-circuit.

What is the constant of an engine having a cylinder 26 ins. in diameter and 60 ins. stroke, with a piston rod 3 13/16 ins. in diameter, running at 67 r.p.m. under a boiler pressure of 100 lbs., and how is it obtained? H. H. W.

An engine constant is the number of indicated horse-power that the engine will develop for each pound of mean effective pressure on the piston; consequently, the boiler pressure does not enter into the calculation. The formula for indicated horse-power is: $\frac{PANS}{33{,}000} = \text{H.P.}$, in which *P* is the mean effective pressure, *A* is the area of the piston; *N* is the number of single strokes per minute, and *S* is the stroke in feet. The mean effective pressure in figuring an engine constant is taken as equal to 1, because the constant is the horse-power per pound of mean effective pressure. The area of the piston is 530.93 sq. ins. on the clear side and 530.93 — 11.42 = 519.51 on the rod side; the average area of the piston, therefore, is $\frac{530.93 + 519.51}{2} = 525.22$ sq. ins. As the number of revolutions per minute is 67 the number of single strokes will be 134; the length of the stroke is 5 ft. Substituting those values in the formula the result is: $\frac{1 \times 525.22 \times 1.34 \times 5}{33{,}000} =$ 10.66, which is the constant of the engine.

A NEW VOLTAGE REGULATOR.

BY W. H. CHAPMAN.

The problem of voltage regulation has been attacked from several sides. The attempt to solve this problem by the indirect method of speed regulation and compound windings of generators has been persistently followed up, but after all that can be done along this line there still remains an important place in central stations and isolated lighting plants for voltage-regulating devices that shall act directly to maintain a constant voltage at any given center of distribution irrespective of variations due to any cause that may operate to disturb the normal working of engine and generator and line. The writer has designed and tested some hundreds of voltage regulators for central stations and isolated plants, each one being a special case and different in some respects from every other one, and the accuracy of results attainable is surprising, especially on alternating-current systems. To control the voltage of the main current of a generating system it is only necessary to regulate the small current, amounting to from one per cent to five per cent of the whole, which is used to excite the field magnet of the generator or generators, and in some alternating-current cases it is only necessary to regulate the still smaller current used in the field-magnet coils of the exciter dynamo. The fact that the current which is varied by the regulation is so small makes it feasible to construct a compact and absolutely reliable regulator as a switchboard instrument, in conformity with the other attachments of the board.

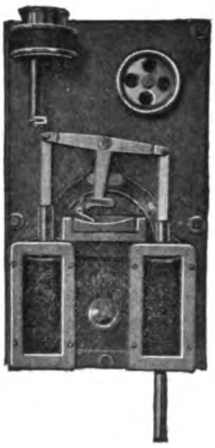

FIG. 1

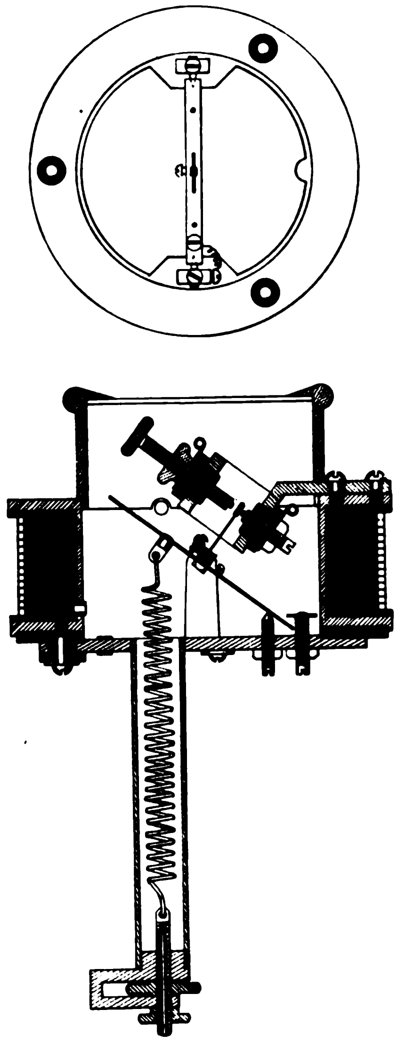

FIG. 2.—DETAILS OF THE RELAY CONSTRUCTION.

Fig. 1 shows a single panel of a switchboard with a voltage regulator attached to it. The original of this cut is a 288-kw regulator, recently constructed, which occupies a panel 28 ins. high and 16 ins wide. An enamel rheostat is placed back of the board and is connected to the copper segments on the front, which are long enough to extend through the board and spread out at the back to make connections with the lugs on the enamel resistance. The upper surface of the segments forms the arc of a circle at the center of which a three-armed lever is pivoted. One arm of the lever supports contact shoes which are held in contact with the segments by coil springs. The contact shoes, in sliding along the segments, vary the amount of resistance in the field circuit of the generator which is being regulated; the contact steps and the resistance material are arranged to present a uniform gradation of resistance and carrying capacity adapted to the work to be done.

The movement of the contact shoes is effected by the two solenoids shown each side of the panel, the iron cores of which are pivoted to the ends of the horizontal arms of the double bell-crank lever. The current for energizing these solenoids is taken direct from the main circuit where the regulated generator is a low-tension direct-current machine. When it is an alternator that is being regulated, current for the solenoid is taken from the exciter. The current at the terminals of these solenoids may vary from 60 to 120 volts without affecting their operation. As long as the delivered e.m.f. is normal no current flows through the solenoids; when the e.m.f. varies, the relay shown at the upper left-hand corner of the panel closes the circuit of one or the other of the solenoids, according to whether the e.m.f. has dropped or risen, and the contact shoe is operated to cut in or out the resistance in series with the field coils connected to the arc of copper contacts.

The movement of the lever is damped by means of an adjustable dashpot shown projecting below the right-hand solenoid. The current required in the solenoid to operate the regulating lever is about one-half ampere. In order to reduce the sparking at the contacts of the relay a special construction is necessary in the solenoids. One method formerly applied by the writer was a differential winding, the current being maintained constantly in one winding and thrown off or on in the other one. A more effective and more easily applied method of eliminating the sparking is employed in the present regulator. This consists of providing short-circuited windings in close magnetic proximity to the operating windings of the solenoid.

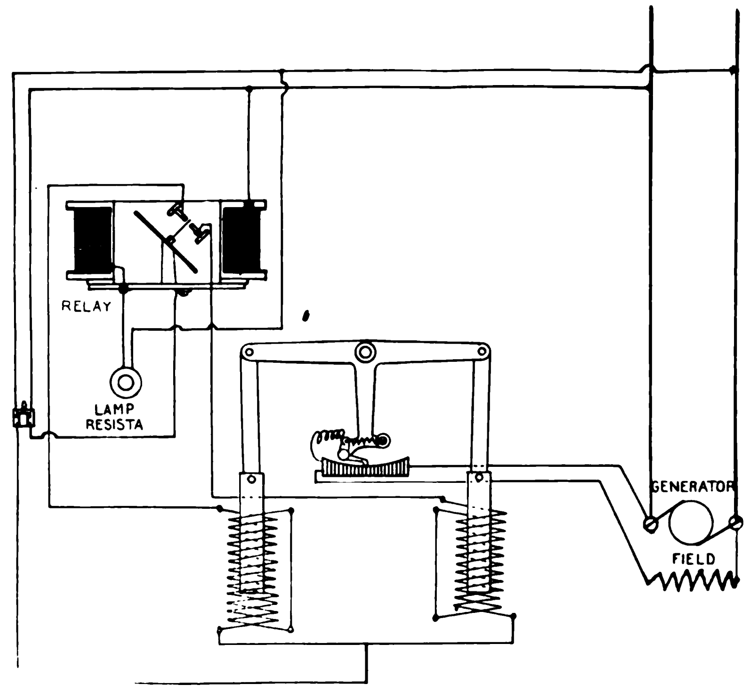

FIG. 3.—DIAGRAM OF CONNECTIONS FOR A DIRECT-CURRENT REGULATOR, WITH THE RELAY FED THROUGH PRESSURE WIRES.

In putting on the winding, four layers of the operating winding are put on first and followed by a layer of insulating paper, then two layers of a wire having twice the diameter of that used in the operating windings is put on; the two ends of this larger wire are brought together and soldered, forming a closed circuit. On top of this winding, a layer of insulating paper is placed and four more layers of the operating winding are put on, followed by insulating paper and another closed-circuit winding, and so on until the spool is filled with alternate sections of operating and closed-circuit windings. This arrangement improves the general insulation of the coil and at the same time supplies each section of the operating winding with an individual closed secondary, the effect of which, of course, is to neutralize the inductive effect of breaking the circuit through the operating winding.

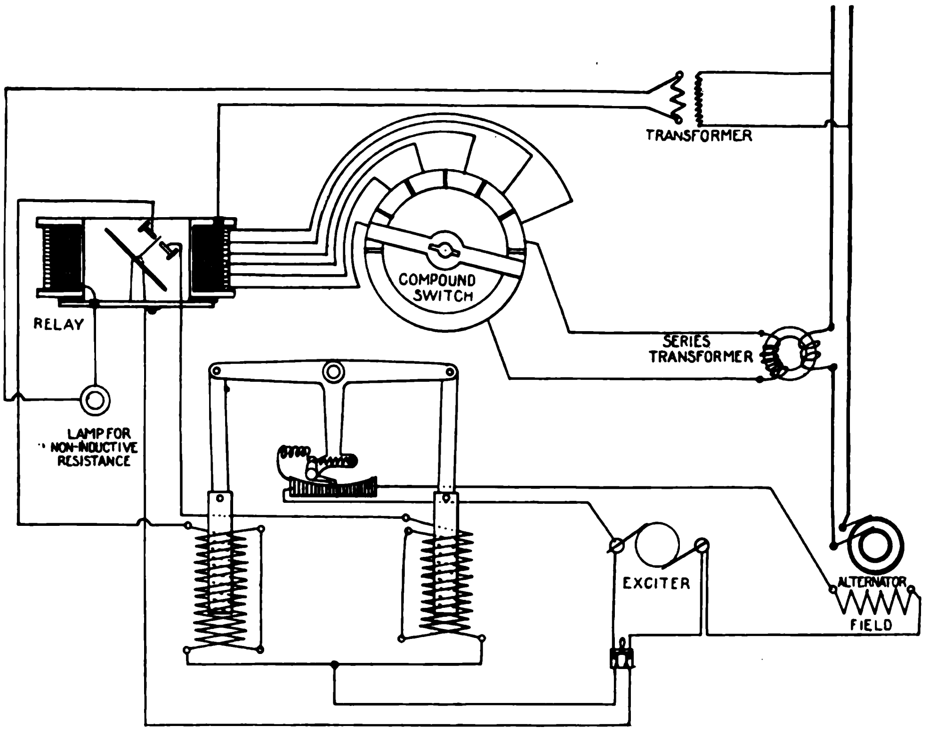

FIG. 4.—DIAGRAM OF CONNECTIONS FOR ALTERNATING-CURRENT COMPOUND REGULATOR.

The relay in the upper left-hand corner of the panel is shown in cross-section by Fig. 2, and comprises a small solenoid wound on a brass spool which is split radially to prevent the circulation of foucault currents when the regulator is used on an alternating-current circuit; within the solenoid is pivoted a sheet-iron disc carrying a contact finger which the current in the coil tends to throw in one direction and the helical spring tends to pull in the opposite direction. The winding of the solenoid consists of a fine wire coil connected in series with an incandescent lamp across the main line when the circuit is a direct-current low-potential one; for alternating-current service the coil and lamp are connected to the secondary of a transformer the primary of which is connected across the main line. The function of the incandescent lamp is to neutralize, by the negative temperature coefficient of its filament, the positive temperature coefficient of the coil; furthermore, when the regulator is used on an alternating-current circuit the lamp tends to render the action of the relay proportional to the voltage despite any changes in frequency due to variation in speed.

In some cases the relay is provided with two windings, a fine-wire winding connected up as described, and a coarse-wire winding which is connected either in series with the main line or to the secondary of a small transformer the primary of which is in series with the main line. For very heavy direct-current circuits a shunt block is used in multiple with the series winding in order to keep the size of the conductor down to rational limits. The relay is adjustable for any voltage within reasonable limits, as the sketch plainly indicates.

Fig. 3 shows the connections of the regulator when used in connection with an ordinary direct-current generator and without a series coil on the relay. The resistance coils connected with the contact blocks are not shown; these are connected up in the ordinary manner common in all rheostats. Fig. 4 shows the connections of a regulator provided with a compensating winding on the relay and arranged to regulate the e.m.f. of an alternator. In this sketch the regulating resistance is connected in series with the exciter armature and the alternator field. It is, of course, obvious that when it is preferable, the regulator can be connected so as to regulate the exciter field. The sketch shows a compound switch arranged to cut in and out sections of the compensating winding on the relay solenoid. This is necessary, of course, in order to adjust the machine for different line drops.

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AN ELECTRICALLY DRIVEN SAW-MILL.

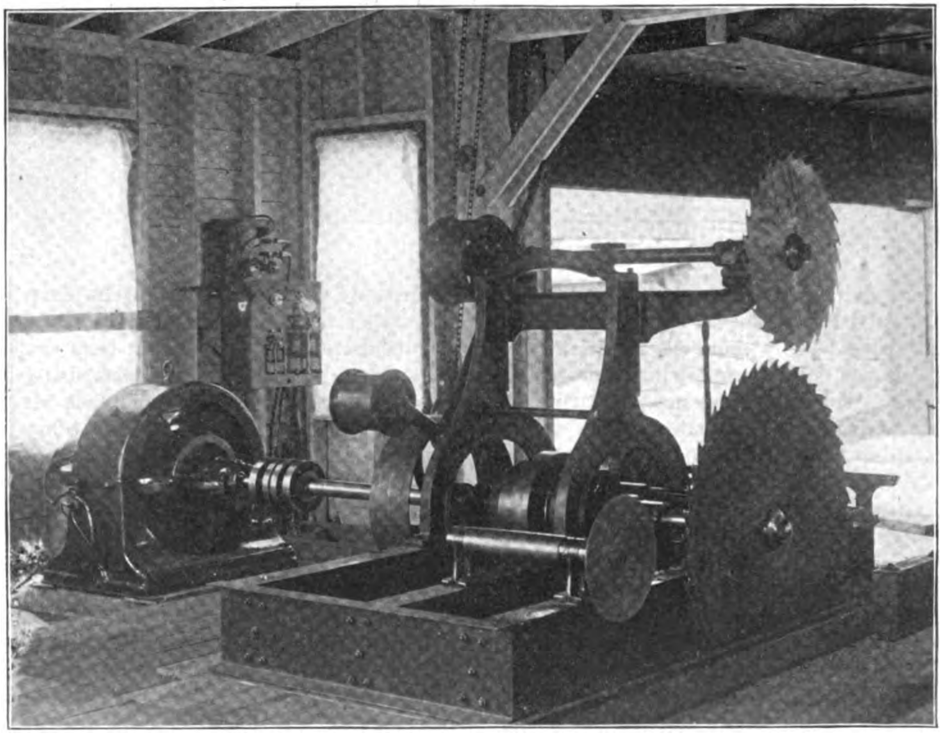

FIG. 1.—ELECTRICALLY-DRIVEN SAWMILL.

Direct-connected elevator service is usually considered as furnishing the most severe conditions under which a stationary direct-current motor may be called to operate, but at the time this opinion became "standardized," so to speak, electric sawmills had not become an engineering factor. The interesting example of direct-connected work illustrated herewith exceeds elevator service both as regards extreme variation of load and necessity for operating under unfavorable conditions as to location and skilled attention. The plant consists of a 35-h.p. New England motor, rigidly coupled to a 48-in. Chase saw-mill. It will be noted that a top saw is provided for use in cutting extra large logs. The speed of the saw is 800 r.p.m.

In this type of motor the armature is carried by a casting independent of the magnet frame, but fitted therein. This casting is bolted to the frame at three points around the circumference, and is provided with longitudinal adjustment for regulating end thrust. This design insures alignment of the bearings, perfect centering of the armature with great stiffness of the frame, and is admirably adapted to meet the severe conditions of this case. The motor is heavily over-compounded. The shaft is extended at the commutator end and provided with a pulley from which is belt-driven a blower for removing the sawdust. What would be normally the pulley end, as stated above, is rigidly connected with the saw arbor by an insulated coupling.

While it was expected that the motor would be subjected to occasional overloads, and the machine was designed accordingly, the actual service demanded of it is considerably more severe than was anticipated, and the following figures may prove interesting. The normal rating of the motor is 135 amperes at 220 volts; when not cutting, and driving the blower only, the current is 30 to 35 amperes; when taking a saw cut the current is constantly and rapidly varying from 50 to 240 amperes. It has been found necessary to lock the overload device on the starting-box, as it operated at 200 amperes maximum. Notwithstanding the unusual demands on the motor, it has operated perfectly, without any extra attention. The brushes require no shifting under the conditions, and the installing engineer reports that they "do not spark in the least."

The generator which supplies the current for this motor was also built by the New England Motor Company, Lowell, Mass., and is known as "Type D." It is a six-pole 230-volt machine, over-compounded and wound specially for this installation. It may be stated in conclusion that both the motor and generator are of standard size and weight, and the excellent results obtained are in no way due to the use of extra large machines adapted for the occasion, as is frequently the case in this work.

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THE HATCH ELECTRIC SMELTING FURNACE.

The general principle of the Hatch smelting furnace is that of putting the raw ore in a closed cylinder with carbon bars heated by the current arranged around the lining of the cylinder, the cylinder being revolved and the carbon bars being cut in and out of circuit as the cylinder revolves, so that no current passes through the ore. Fig. 1 shows the furnace open with one end removed, and Fig. 2 shows the furnace with the end bolted on but with the hole in the center open for charging and for the escape of gases while roasting preliminary to smelting. As can be seen in Fig. 1, the interior of the furnace has seven sets of carbon bars each set of bars forming one side of a polygon, there being ten bars in each set. The ten bars in each set are electrically and mechanically in parallel, and each set is electrically independent of the other sets. Only one set of carbon bars is connected in circuit at one time. The furnace is revolved on the rollers, shown in both engravings, at the rate of one revolution every two minutes.

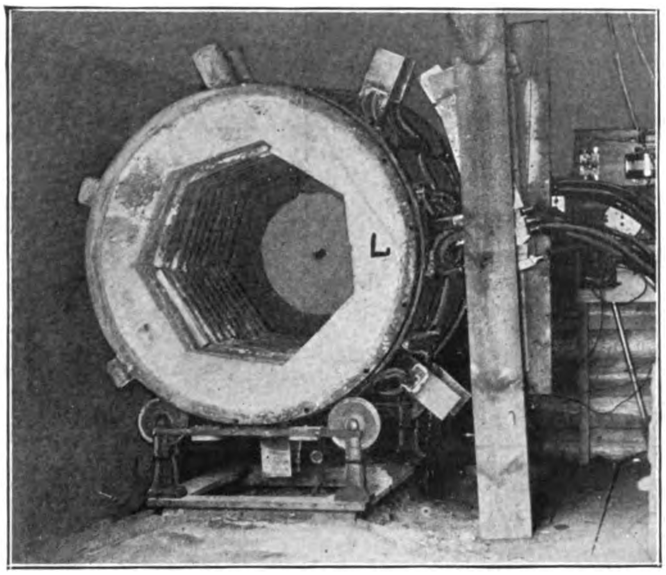

FIG. 1.—ELECTRIC SMELTING FURNACE.

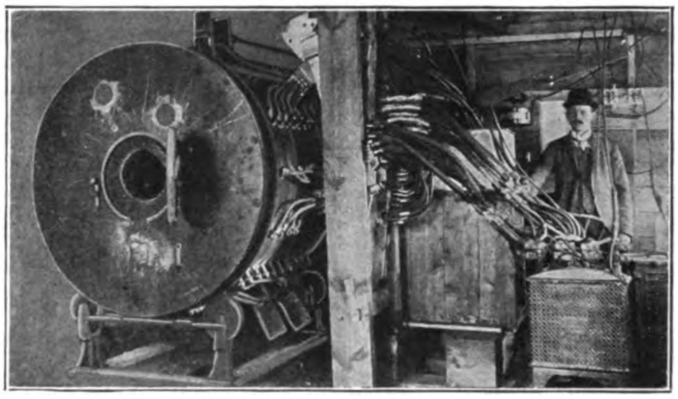

FIG. 2.—ELECTRIC SMELTING FURNACE.

The furnace is filled about one-third full of ore, and is revolved in the direction of the hands of a clock. Projecting radially from the casing of the furnace are seven pairs of switch blades. Each pair is connected to the set of carbon bars nearest to it inside the furnace. As the furnace revolves clockwise, the set of carbon bars which are in the position marked L in Fig. 1, are made live by the contact of the switch jaws of its set with the heavy stationary brushes mounted on the pillar at the right. As soon as the furnace revolves far enough so that the section just mentioned is cut out, the next section above it is cut in, and so on—one section always being in circuit. A current is passed sufficient to bring the carbon up to a white heat. The objects of such a rotary arrangement of furnace are several. By the revolution of the drum the heat is more evenly distributed to the ore, and overheating and volatilization of some portions of the ore has been avoided; the passage of current through the ore itself is obviated, and by doing this a great deal of uncertainty is avoided as to the degree of heat; the ore is constantly being stirred, so that the action is more even on the mass.

Many failures in electric-furnace work, as well as poor results in ordinary smelting of lead and zinc ores, are due to inability to control the heat, and to the overheating of some parts of the mass without sufficient heat in the other parts. The present furnace has been successfully tried, Mr. Hatch says, on refractory lead and zinc ores, which require an exact regulation of the degree of heat, because the metals volatilize at a very low temperature, and overheating causes a loss of metal. In the furnace illustrated the carbons are 1 by 2 ins. in section, and contact is made with them by 1-in. copper bolts. They rest on the firebrick lining of the furnace and are spaced 2 ins. apart, so that the ore falls down between them as well as on top of them, and has good opportunity to absorb heat. Channels are provided under the carbons in the firebrick lining for the smelted ore to run into, and from these it is drained occasionally. The case of the furnace is of boiler iron. The furnace is 4 ft. outside diameter and 3 ft. inside diameter, 5 ft. long outside and 4 ft. long inside. The current taken is 600 amperes at 10 volts, or 60 kilowatts. The furnace will smelt 3 tons in 3 hours—2 hours being taken to roast the ore and 1 hour to smelt it. The roasting is done at a temperature of about 1000° F. on refractory Galena lead ore tested, and it is then raised to 1500° F. to smelt. With energy at 1 cent per kilowatt-hour, Mr. Hatch figures that the cost per ton for smelting is $1.50, against $6 to $8 for smelting direct with coke in the ordinary way. The furnace is built by the Hatch Electric Smelting Company, Green Bay, Wis.

New Apparatus and Appliances

SPRAGUE ELECTRIC HOISTS.

The Sprague Electric Company, of New York, has just put on the market a new electric trolley hoist or travelling crane, two types of which are shown by Figs. 1 and 2. Fig. 1 shows a single-track type equipped with two Lundell motors, one of which drives the lifting gears and the other the traversing gears. The hoisting mechanism is of the well-known Harrington type and each of the motors is of one horse-power capacity. The motors are controlled by the four pendant chains shown in the engraving, the upper ends of which are attached to rocker arms mounted on the spindles of the controllers.

The traversing speed of the carriage is six miles an hour and the hoisting capacity is either 500 lbs. raised at the rate of one foot per second or 800 lbs. raised at a correspondingly lower speed. The pinions of the motors are of rawhide; the weight of the complete crane or hoist is 750 lbs. Particular attention is called to the fact that only 7 ins. of head room is required above the track, and that the wheel base of the carriage is only 10 ins., making it possible for the carriage to turn very short curves.

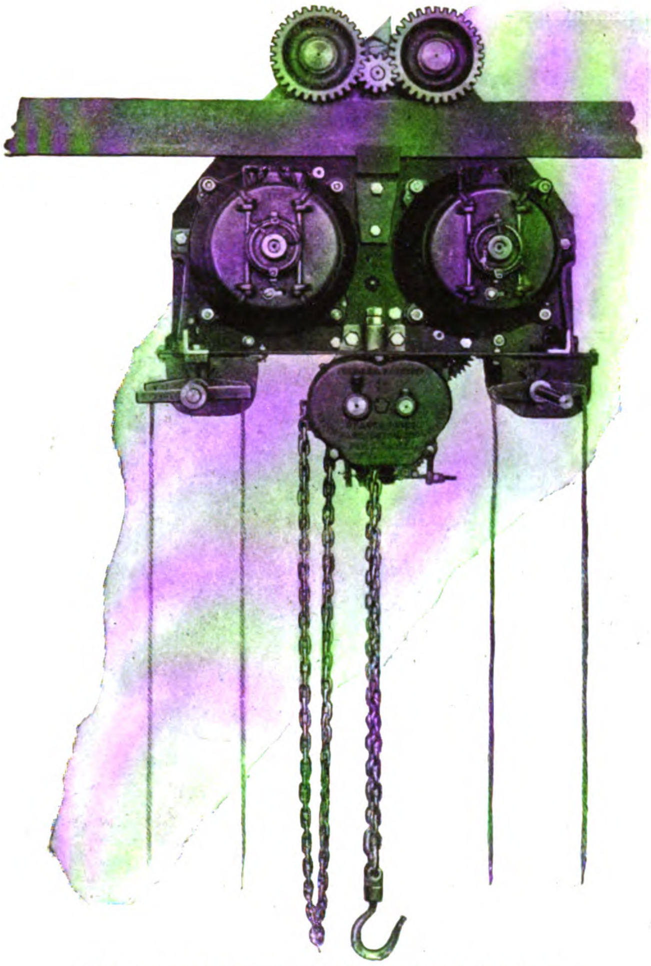

FIG. 1.—SPRAGUE ELECTRIC TRAVELLING HOIST.

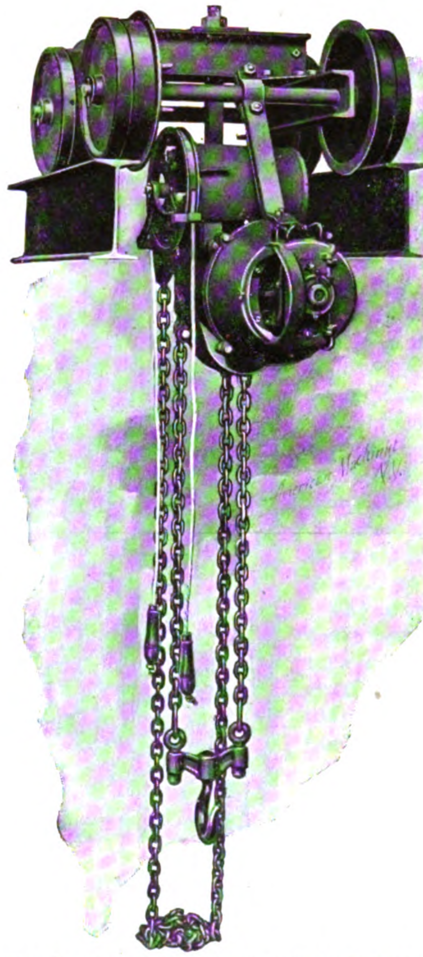

FIG. 2.—SPRAGUE TRAVELLING ELECTRIC HOIST.

Fig. 2 shows a two-track travelling hoist equipped with a single motor which drives the hoisting gear only. The carriage is drawn along its track by hand. The capacity of this hoist is 4000 lbs. raised at the rate of six feet per minute, and the total weight of the outfit is 500 lbs. This hoist has a track gauge of 21 ins. and requires 15 ins. of head room above the track. The motor is controlled, as in the previous case, by two pendant chains. In both forms of hoist, pulling on one chain causes the motor to run in one direction and pulling on the other chain runs the motor in the opposite direction, the current being cut off entirely when the rocker arm is horizontal, as shown in the engraving.

A NEW GASOLINE FIRE-POT.

The Clayton & Lambert Manufacturing Company, Detroit, Mich., has added to its already extensive line of gasoline torches and fire-pots the No. 15 style shown by Fig. 3. As the engraving shows, the furnace is provided with two burners which are of the same construction as that employed in the No. 1 single-burner furnace made by this company. The removal of a spring key permits the top section to be taken off, leaving the flame exposed and allowing the apparatus to be used as a brazing fire or ordinary torcb. This is particularly convenient in thawing out frozen water-pipes and doing similar work. The furnace is guaranteed by the makers to do good work in any kind of weather. It weighs only 10 lbs., so that it is by no means burdensome to carry around from place to place.

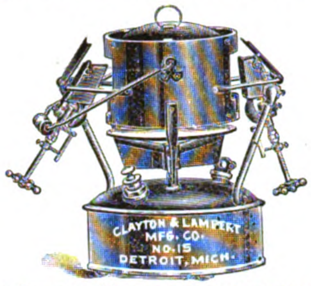
CLAYTON & LAMBERT MFG. CO. NO. 15 DETROIT, MICH.

FIG. 3.—NO. 15 GASOLINE FURNACE.

EUREKA TOLL-LINE AUTOMATIC PAY STATION.

Fig. 4 represents an extremely compact and efficient automatic telephone pay-station built by the Eureka Electric Company, of Chicago, for toll-line service. The instruments are arranged to establish connection by dropping a coin in a slot and they are made to take nickels, dimes or quarters, as may be desired. The automatic slot mechanism is of the simplest type, and the telephone set is supplied for either bridging or series circuits. The receiver of the set is the new Eureka No. 19 instrument which is provided with invisible cord connections on the side, and the magneto generator is a powerful four or five-bar bridging machine. The outfit is

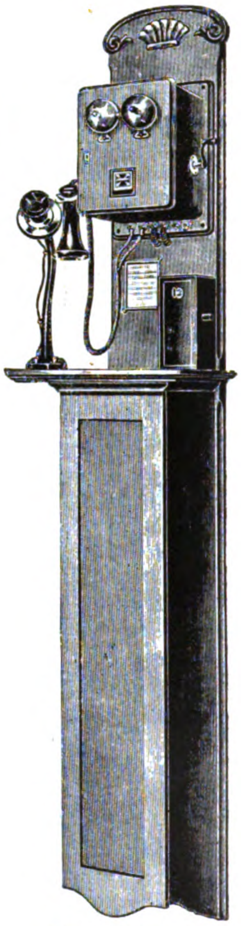

FIG 4.—EUREKA PAY-STATION.

made up in very handsome style and is at the same time very compact and unobtrusive.

ADJUSTABLE HANGING TELEPHONES.

A rather unusual method of mounting telephone instruments has been devised by M. I. Vought, La Crosse, Wis. This consists in suspending the telephones by a cord from a box containing the magneto generator induction coil and signal bells, as indicated by Figs. 5 and 6. Fig. 5 represents the style used when the magneto box is mounted on the wall; in this case the box contains also the transmitter battery. Fig. 6 shows the style of ceiling mounting in which the magneto box contains only the magneto, bells and induction coil, the batteries being rather heavy for this style of mounting. The telephone cord passes up over a pulley on the end of the magneto countershaft (which is geared to the armature shaft in the usual fashion) and thence downward through the counterpoise shown in the illustration and back up to the binding posts within the box. In order to turn the magneto shaft, therefore, it is only necessary to pull the telephone set downward sharply; then it may be raised to any desired height and will be balanced there by the counterpoise. It will be noticed from the illustrations that the transmitter and receiver are mounted on a hand-piece so that when the transmitter is in the proper position for talking the receiver will be opposite the ear. Pressing the spring shown on the side of the hand-piece cuts out the magneto and connects up the transmitter and receiver for talking. In case it is desired to draw the telephone set further away from the box without transmitting a signal it is only necessary to press the spring in the side of the hand-piece. These sets are sent out ordinarily with cords 10 ft. long, but of course the length of the cord can be varied to suit the user.

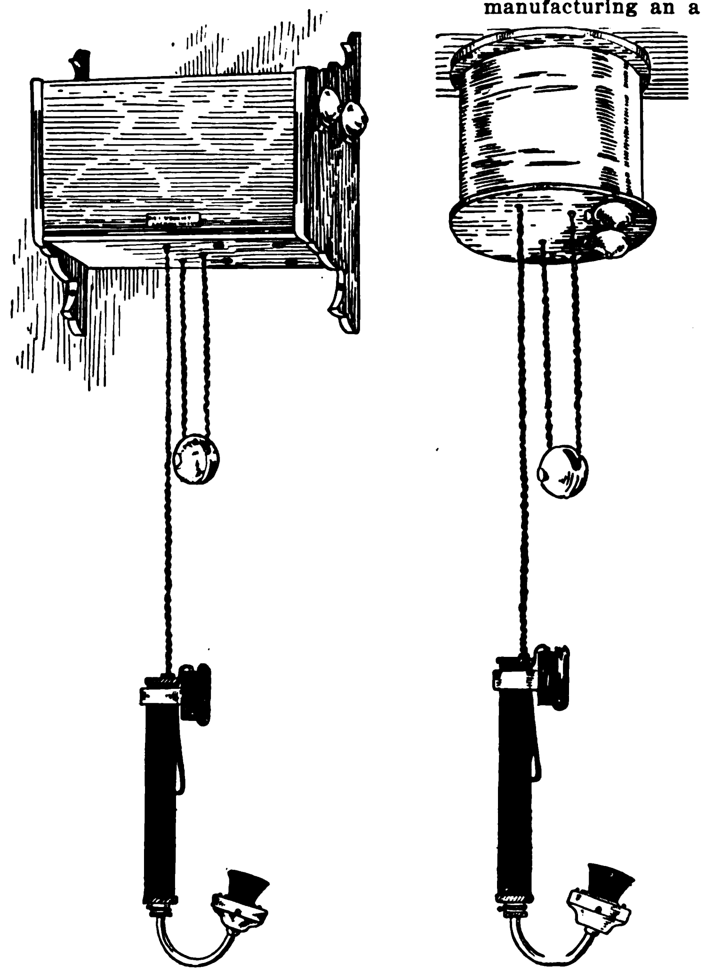

FIG. 5.—HANGING TELEPHONES—FIG. 6.

K. & D. SPECIALTIES

Kendrick & Davis, Lebanon, N. H., are manufacturing an attractive line of low-priced electrical specialties, two of which are illustrated herewith. Fig. 7 shows the K. & D. No. 26 household medical coil which consists of a single-coil inductorium mounted on a round base of highly-polished cherry, together with a pair of nickel-plated electrodes and connecting cords. The coil and vibrator are self-contained, as the illustration shows, and the sparking contacts are of pure silver. The spool heads are of wood finished in bright enamel and all of the metal parts are nickel-plated. Very gradual regulation of the current strength is obtained by the usual sliding member.

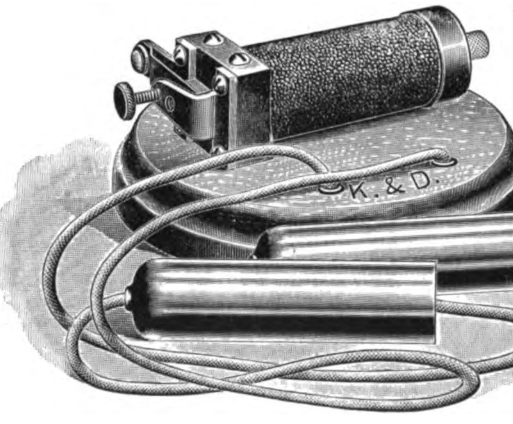

FIG. 7.—HOUSEHOLD MEDICAL COIL.

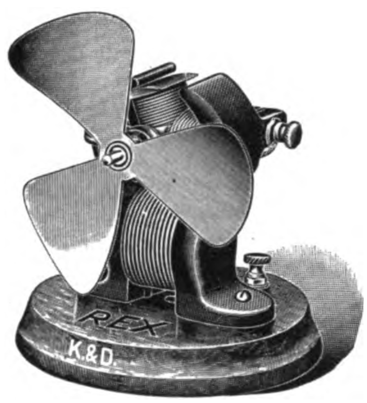

FIG. 8.—REX MOTOR.

Fig. 8 shows the Rex fan motor for battery service. The motor is of the well-known Porter type with a three-pole cast-steel armature and a bipolar field magnet of the same material. This little machine is provided with a smooth japan finish on the iron portions and all of the bright metal parts are polished and nickel-plated The machine, it is said, will run at 4000 r.p.m. on a single cell of dry battery.

THE CHASE FLEXIBLE CONDUIT COUPLING.

The conduit coupling illustrated by Figs. 9 and 10, and manufactured by the Chase-Shawmut Company, Boston, Mass., was designed specially for use in connection with flexible steel conduit, and the claims made for it are that its use, in conjunction with the Chase nipples, shown by Fig. 11, will secure the conduit to an outlet box, a switch box, or a junction box, and will not

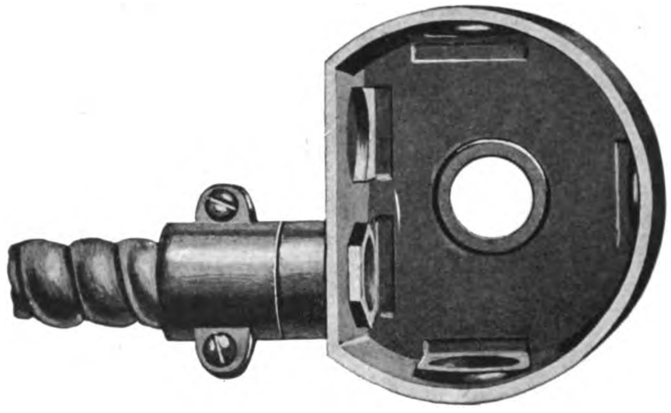

FIG. 9.—APPLICATION OF CHASE COUPLING.

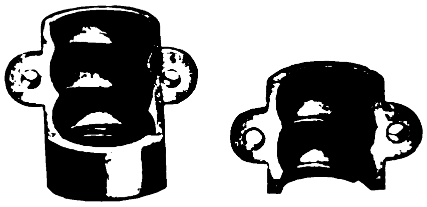

FIG. 10.—CHASE COUPLING.

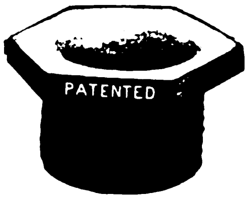

FIG. 11.—CHASE NIPPLE.

pull out or allow the conduit to push into the box. The coupling makes a smooth rounded terminus for the wires to lead from, and projects only ⅛ in. inside the box, leaving plenty of room for connecting switches, etc. It can be applied to any standard knockout box now on the market; no drilling or tapping of the box is required, and the only tools needed to apply the coupling to a box are a screwdriver and a pair of pliers. The Chase flexible conduit coupling will also join flexible conduit to iron-armored conduit, preserving the continuity of the smooth interior.

A NEW EMERSON MOTOR.

The Emerson Electric Manufacturing Company, of St. Louis, Mo., has brought out a new line of induction motors ranging in size from 1/10 to 1/3 brake horse-power. The armature, or revolving member, of these motors is of the squirrel-cage type, and the stator is provided with two windings, one being used for starting. The design of these motors is a compromise between the employment of a starting winding which will give the motor full-load starting torque, and the use of a starting winding which will give it a very slight starting torque, so that it will not always start with the belt on without assistance. In the former case the starting winding is necessarily of such a character that if it is left in circuit for any length of time it will burn out; in the latter case there is no danger of burning out the starting coils, but the starting of the motor is very uncertain. In the type under discussion the compromise between these two extremes results in a motor which will start readily with the belt on, but without load, and at the same time without danger of burning out the starting coils. These motors take much less starting current than would be possible if they were built to start under load, of course. They are built in two styles, one style being provided with a three-step grooved pulley on the armature shaft and the other style being back-geared, with the main driving pulley on the countershaft, as represented by Fig. 12. The armature shaft projects beyond the casing, as shown, so that if it should be desirable a pulley can be mounted there, and two pieces of apparatus driven at different speeds. These machines are built for 104 volts and for frequencies of 50, 60, 100 and 133 cycles. The motor speeds range from 450 to 1800 r.p.m., according to the size of the motor and the frequency of the circuit. The ratio of the gears is 5 to 1, so that the countershaft runs at one-fifth of the motor speed.

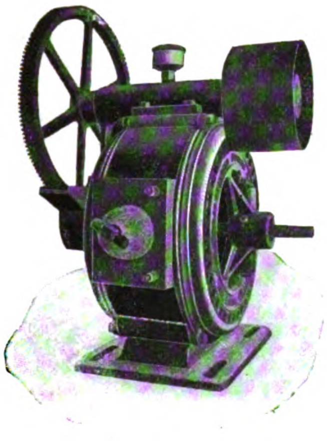

FIG. 12—EMERSON MOTOR

A NEW STURTEVANT VENTILATOR.

The B. F. Sturtevant Company, of Boston, Mass., has brought out a new form of ventilating fan direct-driven by a slow-speed motor, as represented by Fig. 13. The fan wheel is provided with a large inlet through one side only and has curved blades and a conoidal plate concentric with the inlet, which serves to gradually deflect the air from the axial direction in which it enters to a radial direction of motion.

A self-oiling journal box is located in the air inlet which supports that end of the fan shaft; the other end is coupled rigidly to the motor shaft and is supported therefore by the motor bearings. The motor is an 8-pole machine with a wrought-iron field ring. The field-magnet cores are also of wrought iron with cast-iron pole pieces. The armature is of the usual slotted-core type with form-wound coils.

This type of fan is designed for use without a casing, being usually mounted so as to draw the air through an opening in a wall and discharge it radially from the fan blades at a comparatively low velocity into the room to be ventilated, in which is located the fan and the motor.

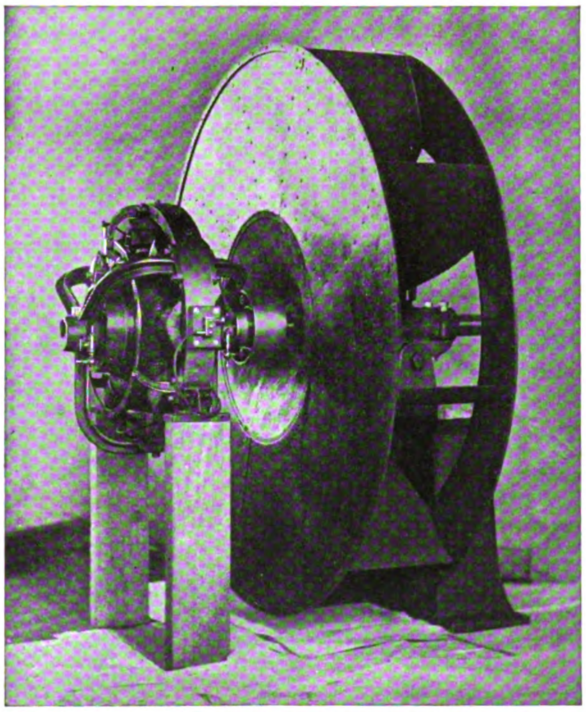

FIG. 13.—STURTEVANT VENTILATING OUTFIT.

TRIUMPH PRINTING-PRESS MOTOR.

The Triumph Electric Company, Cincinnati, Ohio, is building a special line of slow-speed motors adapted for direct coupling to job printing-presses, one of which is illustrated by Fig. 14. The press here shown is known as a three-color chromatic jobber and its maximum ability is 2400 impressions an hour. The motor is of the circular-yoke multipolar type and runs at 128 r.p.m. when driving the press at its maximum rate of 2400 impressions. The motor is provided with a controller by means of which the speed can be cut down to one-half of the maximum and a number of intermediate speeds obtained.

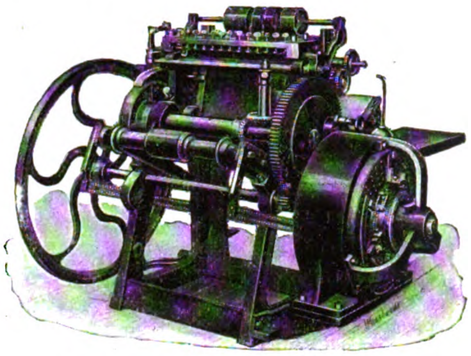

FIG. 14.—TRIUMPH PRINTING-PRESS MOTOR.

The rim of the motor is of soft, close-grained cast-iron. The magnet cores are of the laminated type, fitted with cast-iron shoes to increase the area of the air-gap and provide a good commutating fringe. The thin iron sheets composing the magnet cores are specially treated before they are put together and then riveted together and cast into the yoke. The armature core is mounted on a cast-iron spider and is of the usual toothed type. The discs are carefully annealed before being mounted on the spider in order to reduce to a minimum the core losses. The armature coils are form-wound and of the interlacing type, similar to the Eickemeyer pattern, so that every coil is of the same length. The commutator shell is of cast-steel of somewhat unusual construction; the back shell extends completely under the segment and has a turned projection which carries the front shell. This forms an oil groove or chamber, making it impossible for the oil to creep along the shaft and get in the interior of the commutator.

The armature core is ventilated in the usual manner and the magnet and armature are enclosed at each end by a flat circular cap which is perforated for ventilation. The commutator and brushes are not enclosed by the cap, but are left outside for convenience in attendance. The brush-holders are mounted on the end cap of the motor instead of on the outside of the journal box, and what little adjustment may be necessary is obtainable by rotating the cap, a hand wheel being provided for this purpose. The bearing at the commutator end is carried by a three-arm spider, as shown.

The motor here shown is a 1-h.p. 6-pole machine, the unusual number of poles being necessitated by the slow speed, of course. In larger sizes these direct-connected motors are of the same general construction and type but are provided with eight poles.

MIETZ & WEISS KEROSENE ENGINE.

Fig. 15 represents a very compact form of kerosene engine built by August Mietz, of New York. The engine is of the two-cycle type and therefore gives an impulse to the crank at every revolution as long as the load is normal. Regulation is effected by means of a modification of the pendulum pick-blade type of governor, arranged to actuate a small pump which injects the fuel oil into the cylinder; when the speed is excessive the pendulum throws the pick-blade out of reach of the pump spindle and no oil is injected into the cylinder. The oil is vaporized by being thrown on a conical plate located in the chamber which is shown projecting from the back end of the cylinder; this plate is kept heated by the successive explosions during the operation of the engine. The fuel tank (see Fig. 16) is located above the crank case and the oil first passes through a filter before going to the pump which injects it into the cylinder. The lubricating oil is contained in a reservoir mounted on the side of the engine, as shown, from which it is led by pipes to the piston and crank-pin oilers. The main bearings are lubricated by means of ring oilers of the type employed on dynamos and motors. The crank case is so nearly air-tight that the withdrawal of the piston into the cylinder on the back stroke creates sufficient vacuum in the case to cause the lubricating oil to be forced in by atmospheric pressure, the result being entirely automatic lubrication as long as the engine is running and a stoppage of the flow of oil when the engine stops.

As there is an impulse at every revolution, the two-cycle type of engine is more easily governed than the four-cycle type, in which there is an explosion only once in two revolutions, and this renders the two-cycle engine particularly well adapted to the driving of dynamos, where closer regulation is naturally required than in ordinary engine work. The Mietz & Weiss engine has made a good record in this class of work, a number of these engines having been employed direct-connected to dynamos for lighting service.

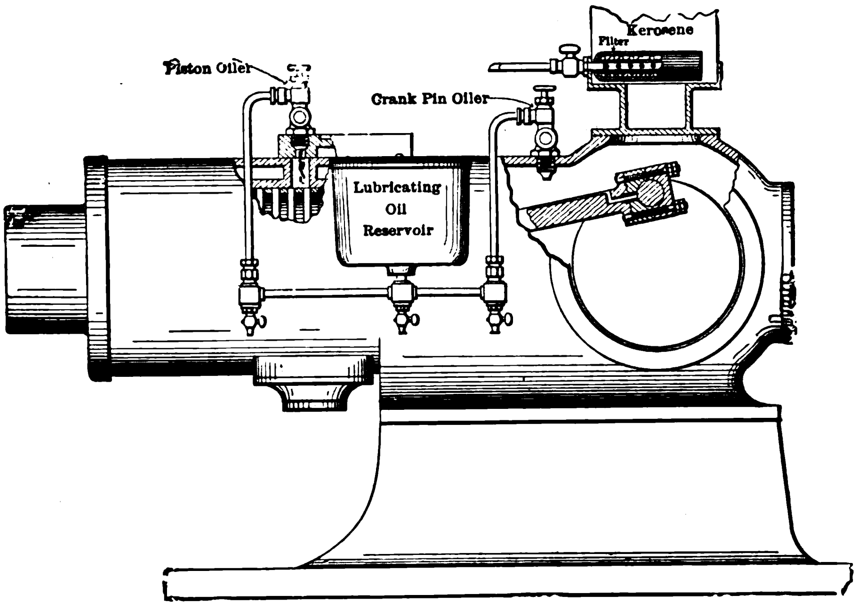

FIG. 16.—MIETZ & WEISS KEROSENE ENGINE.

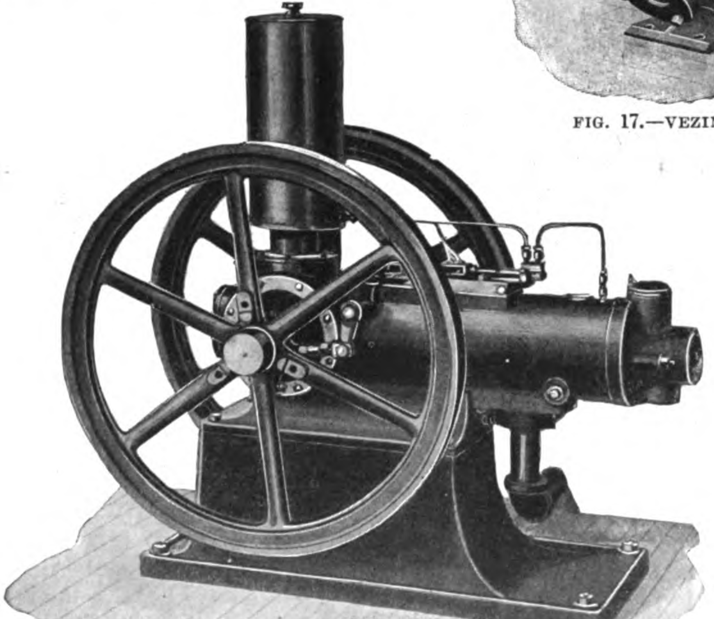

FIG. 15.—MIETZ & WEISS KEROSENE ENGINE.

A NEW HIGH-SPEED ENGINE.

Figs. 17 to 19, inclusive, represent an ingenious and unusual type of high-speed steam engine which is now being built in sizes ranging from 5 to 25 horse-power by the Vezin Machine Company, of New York. Fig. 17 gives an exterior view of the complete engine; Fig. 18 shows a side view with one of the enclosing plates removed; and Fig. 19 shows the pistons and crank removed from the frame of the engine.

There are four single-acting cylinders arranged radially and equidistantly about a common center, as indicated in Fig. 18. The pistons of opposite cylinders are connected rigidly together and between them is provided a sort of crosshead in which slides a brass box mounted on the crank-pin, as shown by Fig. 19. This arrangement is employed in order to obviate the use of connecting rods, and it will be familiar to engineers who have handled rotary pumps built after this plan. The crank is counterbalanced, as shown in the engraving. A view of the valve-gear is shown in Fig. 18.

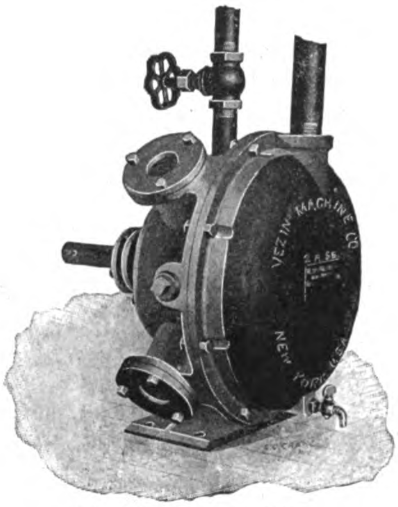

FIG. 17.—VEZIN ENGINE.

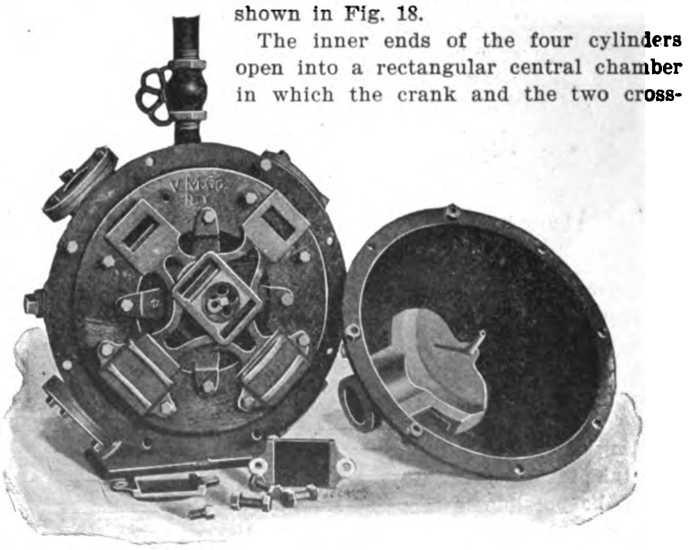

FIG. 18.—INTERIOR OF VEZIN ENGINE.

The inner ends of the four cylinders open into a rectangular central chamber in which the crank and the two crossheads operate. This chamber is separate from the main chamber enclosed by the outer casing, and is provided with an in-

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A MODERN CANADIAN WATER-POWER PLANT.

THE MONTMORENCY FALLS GENERATING STATION.

An extremely interesting power station, and one in which is incorporated thoroughly modern features, is that of the Quebec Railway, Light & Power Company, situated at Montmorency Falls, Canada, seven miles east from the city of Quebec. The Montmorency River, which has its origin about 75 miles above the Falls, provides an ample supply of water in the dryest seasons of the year, it is said, to develop 10,000 horse-power. A dam was built on the verge of the Falls, which have a drop of 284 ft. into the St. Lawrence River. A useful head of 200 ft. is utilized at the power house. The shape of the dam is rhomboid; the side which faces up stream is built of concrete in order to enable it to withstand freshets and the accumulation of ice in the winter season. The length of the dam is 265 ft. between shore piers; it is 18 ft. high, 22 ft. thick at the bottom and 8 ft. thick at the top. The mixture of concrete used for the interior of the dam is one part Portland cement, three parts sand, and five parts broken stone; for the facing, the mixture is one part cement, two parts sand and three parts stone, the facing being 12 ins. deep.

In order to secure adequate protection against anchor ice the west side of the river in front of the dam was converted into a still-water pond by building a crib 325 ft. long, substantially parallel to the flow of the river in front of the dam and containing seven submerged openings 6 ft. x 12 ft. each for the entrance of water from the river proper into the "fenced-off" portion. In this cut-off portion of the river, which may be referred to as the pond, the entrance to the feeder pipe is located. The crib, which is illustrated by Fig. 2, is sheathed with heavy planking on the side next to the open part of the river in order to deflect ice and debris.

The feeder pipe, or flume, which conveys water from the pond in the river above the dam to the power house, is a steel pipe 2609 ft. in length; 1509 ft. of the flume is 8 ft. in diameter, with a ¼-in. wall, and has only a slight percentage of slope; the remaining 1100 ft. is 6 ft. in diameter, with a ⅜-in. wall, and has a considerable slope. The seams around the circumference are single-riveted, and the horizontal seams double-riveted. When all the turbines are running on a peak load the rate of flow in this feeder pipe is about 5 ft. per second.

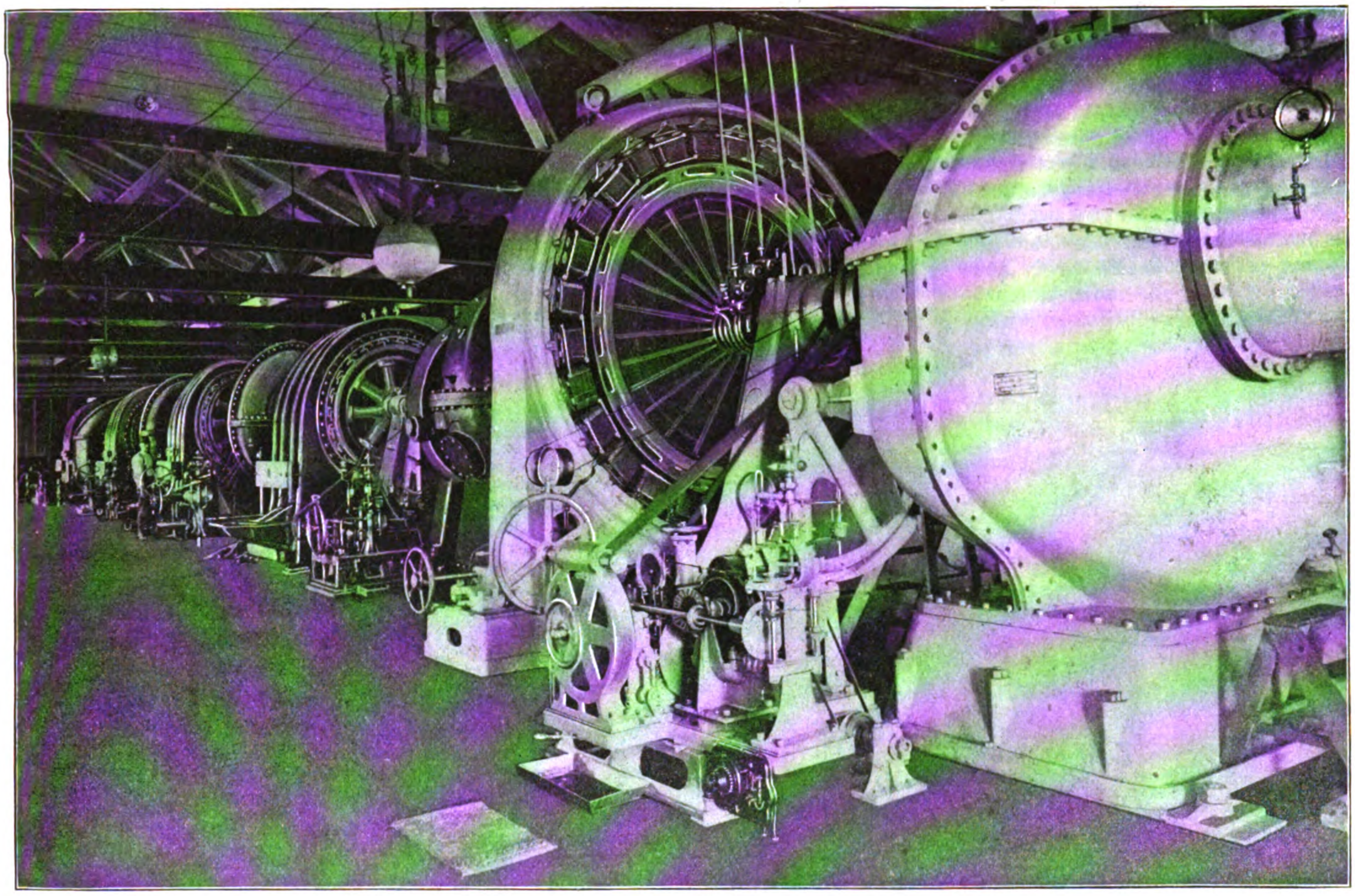

FIG. 1,—VIEW IN THE POWER HOUSE, SHOWING DOUBLE-CURRENT GENERATOR AND ITS TURBINE IN THE FOREGROUND.

It was found necessary to provide protection against the checking of the flow of water, due to closing the turbine gates, the prime object, of course, being to avoid a rupture of the pipe, and the secondary object being to facilitate the regulation at the station. To this end two stand-pipes were provided, one being placed almost immediately outside of the power house. The foundation for this stand-pipe is 75 ft. above the power house, and the stand-pipe itself is 150 ft. high and 6 ft. in diameter. The second stand-pipe was erected midway between the dam and the power house and is 4 ft. in diameter and 45 ft. high. Both stand-pipes were housed from top to bottom with a 4-in. air space inside the housing to prevent freezing during the winter season. This arrangement has proven exceedingly satisfactory.

The power house is a substantial stone structure two stories high, with a floor area 40 x 150 ft. The turbines used here are the first of their kind ever put into service. They are Victor wheels, and were designed by the Stilwell-Bierce & Smith-Vaile Company especially for the high head under which they are used. There are five turbines, each 54 ins. in diameter, running normally at 286 r.p.m. under a 200-ft. head, and developing 1000 horsepower each. Fig. 5 is a diagram giving power and efficiency curves taken at an official test of the wheels, made by independent engineers for the Quebec Company. The figures on the diagram are self-explanatory and require no comment.

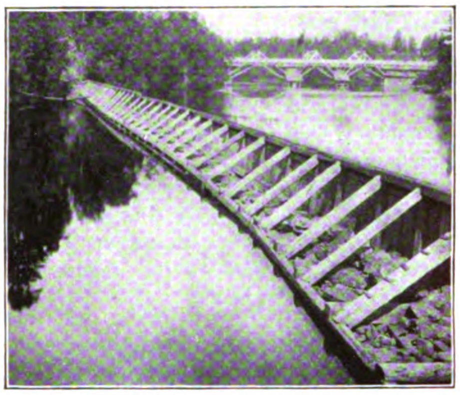

FIG. 2.—THE HYDRAULIC CRIB.

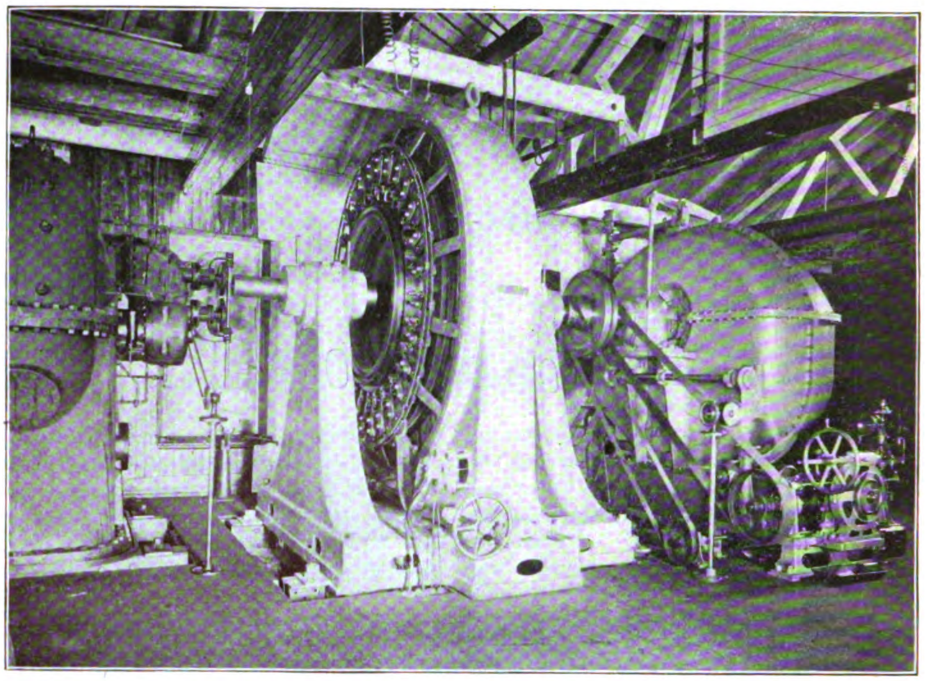

FIG. 3.—DOUBLE-CURRENT GENERATOR.

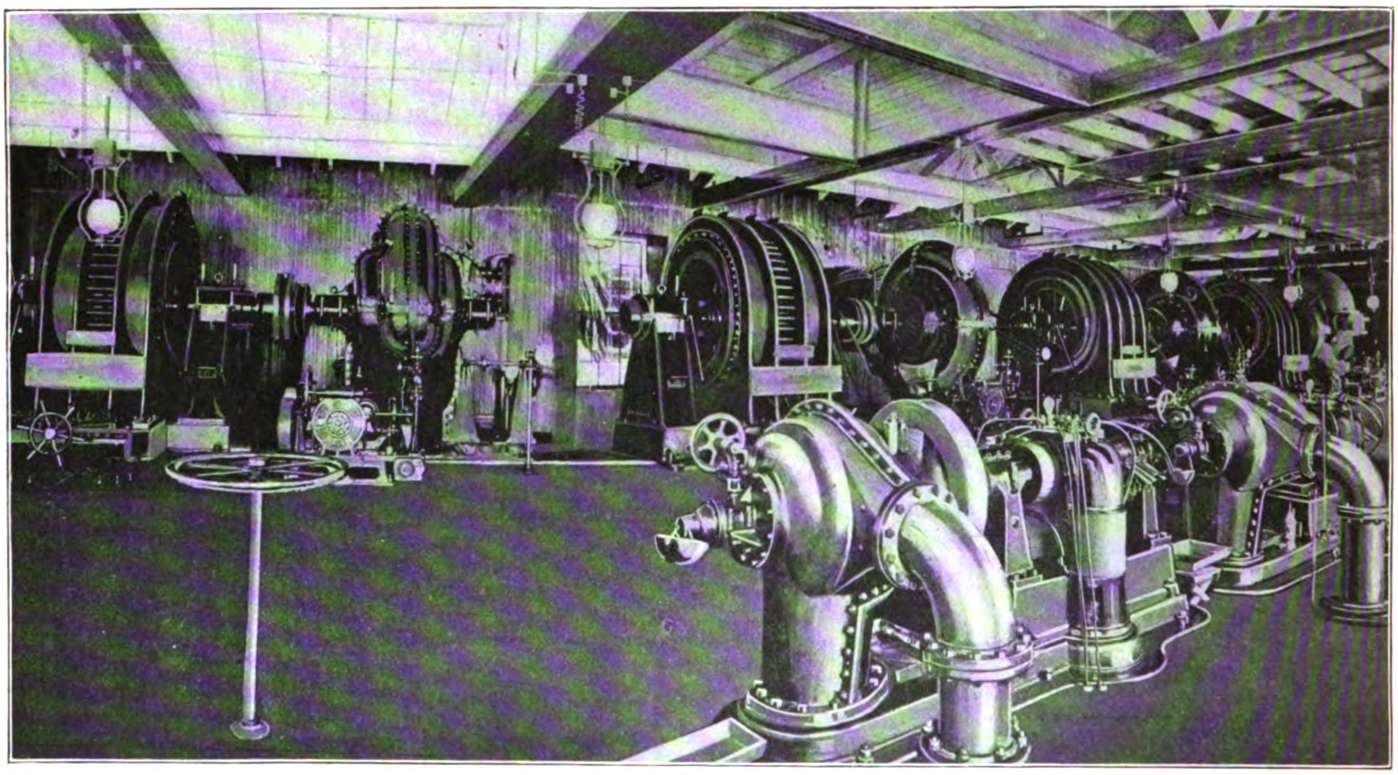

FIG. 4.—BROADSIDE VIEW IN POWER HOUSE; EXCITERS AND THEIR TURBINES IN FOREGROUND.

Each turbine shaft is coupled direct to the generator shaft through an insulated flange coupling. Speed regulation is obtained by the use of Giesler electro-mechanical governors, which are said to keep the speed with a maximum of 3 per cent variation in 286 revolutions; that is to say, within the space of one minute; on ordinary loads the variation is said to be kept within 2 per cent. In the event of any sudden removal of the load, by reason of the opening of a circuit-breaker, for example, the governor closes the gate within three seconds to an opening sufficient to keep the wheel running at normal speed.

The generator equipment consists of five units, four of which are Stanley-Kelly two-phase inductor alternators, three of which develop 600 kilowatts at 5500 volts, and give a frequency of 66 cycles per second. The fourth alternator is a 720 kw. machine; the frequency is the same. In addition to the alternators there is a 600-kw. Westinghouse double-current generator, shown by Fig. 3, which gives two-phase alternating currents at 400 volts and 66 cycles on one side and 500-volt direct current on the other side. The alternating e.m.f. is raised by step-up transformers from 400 to 11,000 volts, and the currents are transmitted to Ste. Anne's de Beaupre, 15 miles distant, over a three-wire line. At the other end the e.m.f. is reduced by step-down transformers to about 400 volts and delivered to a rotary converter, which supplies current to that end of the railway system. This system has also a feeder from the Quebec end of the line, so that the distribution is unusually uniform. The direct-current side of the double-current generator at the power house supplies current to the railway line running past the station.

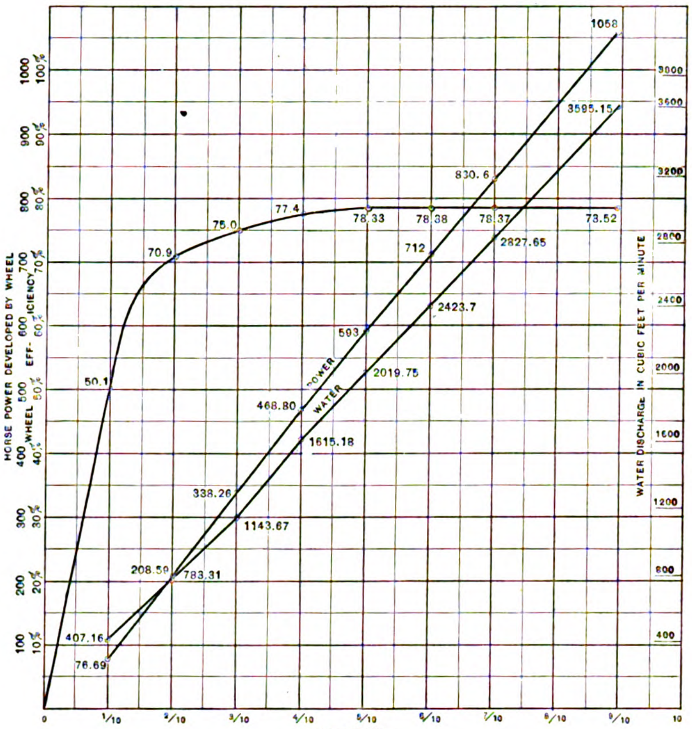

FIG. 5.—CURVES PLOTTED FROM TEST OF TURBINE.

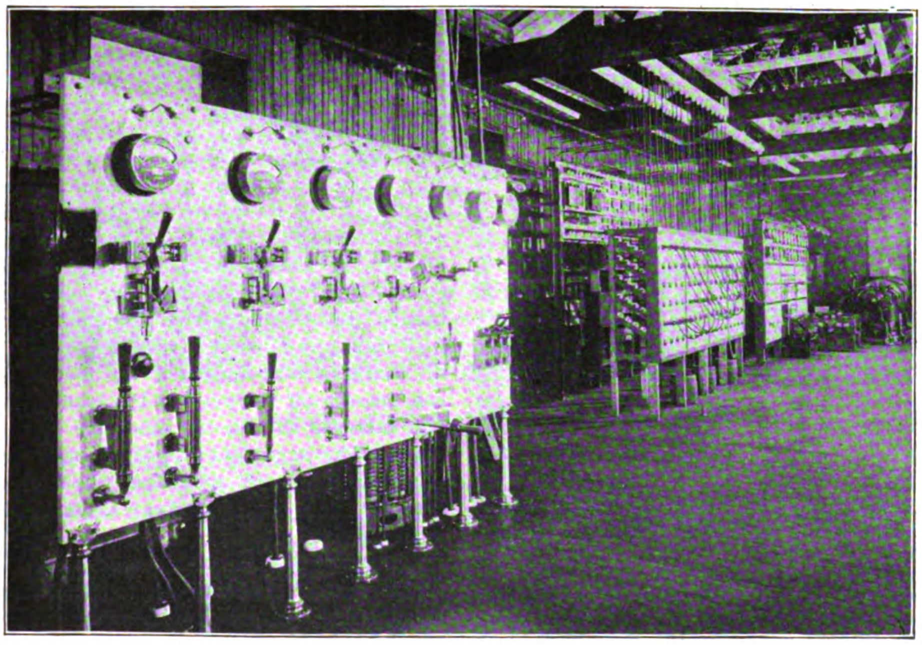

FIG. 6.—THE SWITCHBOARDS.

The four purely alternating-current units have an independent switchboard, comprising nine marble panels set in an oak frame and equipped with the usual outfit of voltmeters, ammeters, circuit-breakers, switches, etc. There are two bi-polar exciters, shown in the foreground of Fig. 4, which were built by the Royal Electric Company, of Montreal, who also built the 720 kw. alternator. The switchboard arrangement is such that any of the generators may be supplied from either one of the two exciters. The double-current generator has an individual switchboard comprising six marble panels, with the usual outfit of indicating instruments, switches and circuit-breakers. The circuit-breakers are the I-T-E type, made by the Cutter Electrical & Manufacturing Company, Philadelphia. The high-potential transmission lines are equipped with three special non-arcing circuit-breakers, and all of the lines are protected by Wurts pyramidal lightning arresters with auxiliary choke coils.

DETERMINING TORQUE FROM STEAM ENGINE INDICATOR CARDS.

When electric motors were put in to replace steam engines for running the cable plant of the Ninth Street cable line at Kansas City a rather unusual proceeding was required to predetermine the current and torque that would be required of the motor to be put in. The running torque could of course have been determined by taking indicator cards on the engine while the cable was in regular operation, though, owing to the rapid fluctuations of load on the cable, even this would have been difficult. The running torque, however, was not the thing most desired. What was wanted most was to find what it would take to start the cable from a standstill under such conditions as would exist should a circuit-breaker open when the cable was in regular operation and make it necesary to start up from a dead stop. To do this a series of indicator cards were taken on the cable engine starting from a standstill, with all the lost motion taken out of the gears. The engine crank was put at exactly half stroke and steam was admitted to the cylinder gradually until the engine would just start the cable.

The pressure shown on the indicator card at the instant of starting was noted and this process repeated until a number of indicator cards were obtained. From these a fair average could be calculated. The torque exerted by the engine was then figured from the total steam pressure on the piston head at the instant of starting. From this the starting torque to be required from the electric motor when geared at the proper ratio to run the cable at normal speed was obtained and this was compared with the torque the motor would exert when running at its rated speed and horse-power. Then, by allowing a good margin for overloading the motor, the current required to start the motor and cable machinery from a standstill was determined.

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THE 4-C METHOD OF CHARGING FOR ELECTRIC CURRENT.

BY RALPH J. PATTERSON.

Under certain conditions of prosperity such as exist in large electric lighting plants in cities, there is no need to consider a method of charging for current devised to encourage business, the time of the management being occupied in keeping the plant equipped to take care of a constantly increasing demand for the service. On the other hand is the small plant looking for an increase in business without any definite plan as to how best to approach its customers in order to induce such increase, and where new customers can rarely be found who will be satisfied that they are not being robbed by a grasping corporation. It is said that "goods well bought are half sold"; in central station work this may be paraphrased to read, "goods well offered are half bought."

How then shall we sell current? By contract or flat meter rate? In units of a lamp-hour, horse-power-hour, ampere-hour, or watt-hour? We cannot depend on contracts for a basis wherever the number of lights varies from time to time or the time for which they are in use. It is difficult to induce people to use service freely with a flat meter rate, even when the rate is very low. Sliding discounts are an improvement, but generally complicated. A method is here presented in which it is endeavored to combine the good points of a contract and sliding discount system in such a way as to be more generally applicable to plants where other systems could not be put in operation.

The method consists broadly in charging the consumer a fixed sum per annum for the maximum demand which he purposes making upon the station, in addition to the meter charge, which is much lower than the usual meter rate. This fixed charge is based roughly on the interest and depreciation charge of the plant. For example, assume a small electric-light plant of 150 arcs and 5000 incandescents; the value of the plant will be about $65,000, and the interest and depreciation charge consequently about $6500. Incandescent lamps should average 700 lamp-hours per year, or say 3000 watt-hours per month and 36,000 watt-hours per year.

Neglecting street lighting, the income from the 5000 lamps should average $1.30 each per year to cover interest and depreciation, after which current can be sold at a very low price with a profit, besides encouraging consumers to use the service freely. However, it will not be judicious to make the fixed charge as small as above, because the capacity of the plant may not be fully demanded, although the investment has to be carried as if it was. It is perfectly safe to sell all the capacity of the plant as a demand, because it will never be found that all will want the full capacity of their demand at one time. It will, however, be safer to estimate the average income from the fixed charge at $2 per lamp demanded, as the investment in many plants will exceed the figures given. The income from such a plant would then be something like this:

Incandescents.

Fixed charge for 5000 lamps at $2........	$10,000
Current charge 180,000 watt-hours at 5c.	9,000
Equivalent to 180,000 watt-hours at 15½c.	$19,000
150 arcs at, say, $70........................	10,500
Total	$29,500

In small plants the operating expenses and fixed charges are often larger in proportion than in large plants. If then, one has enough customers the smaller the demand per customer the larger the income from the fixed charge. For example, a plant of 50 arcs and 1200 incandescents, representing an investment value of, say, $20,000, would have an interest and depreciation charge of about $2,000, or $1.65 per incandescent lamp capacity. The income from such a plant would be:

Incandescents.

Fixed charge for 1200 lamps at $2........	$2,400
Meter charge, 43,200 kw.-hours at 5c....	2,160
Equivalent to 43,200 watt-hours at 15½c.	$4,560
50 arcs at, say, $80........................	4,000
	$8,560

Under the proposed plan the customer chooses the demand based not on the number of lamps installed but on the maximum number to be used at any one time. In order to carry out this method it is necessary, of course, to have some check on the customer so that the maximum demand number will not be exceeded. This may be accomplished by means of sealed fuses, circuit-breakers, dimmers, etc.

The essential feature of the plan, as intimated above, is to charge each customer a fixed amount, scaling this amount according to the demand of the customer. Table I gives a schedule which has been successfully used for domestic lighting, and Table II gives a smilar schedule for commercial lighting. It must be borne in mind that these tables represent only the fixed charge, there being an additional meter charge for the actual consumption; this meter charge, however, is made at an extremely low rate, so that in cases where the demand is a fair figure the total amount paid by the consumer is no more than he would pay under the ordinary straight meter rate. For example, suppose a residence in which the maximum number of lamps used is five should show a consumption of 75,000 watt-hours in a year. At 20 cents per 1000 on the straight meter plan the aggregate of the bills for that year would be $15. Under the plan here proposed, with a meter rate of 5 cents per 1000 watt-hours (10 cents per 1000, with a rebate of 5 cents if paid by a certain date) the fixed charge would be $15 a year and the meter charge $3.75 per year, making a total of $18.75 compared with $15 by the straight meter plan. A consumption of 75,000 watt-hours a year for five lamps, however, is very small, even for a residence, and if this were increased to 100,000 watt-hours the year's bills would figure up $20 in both cases. Any increase beyond 100,000 watt-hours would show charges in favor of the plan here suggested.

TABLE I.—CAPACITY CHARGE SCHEDULE FOR RESIDENCES.

Demand in 16-c.p. lamps.	Per lamp, per year.	Yearly charge.	Average monthly charge.	Monthly charge, winter.	Monthly charge, summer.
1............	$9.00	$9.00	$0.75	$0.90	$0.45
2............	5.00	10.00	.85	1.00	.50
3............	4.00	12.00	1.00	1.20	.60
4............	3.25	13.00	1.10	1.30	.65
5............	3.00	15.00	1.25	1.50	.75
6............	2.90	17.40	1.45	1.75	.85
7............	2.80	19.60	1.60	1.95	1.50
8............	2.70	21.60	1.80	2.15	1.10
9............	2.60	23.40	1.95	2.35	1.15
10............	2.50	25.00	2.10	2.50	1.25
11............	2.40	26.40	2.20	2.65	1.30
12............	2.30	27.60	2.30	2.80	1.35
13............	2.20	28.60	2.40	2.90	1.40
14............	2.10	29.40	2.45	2.95	1.45
15............	2.00	30.00	2.50	3.00	1.50
16............	1.95	31.20	2.60	3.15	1.60
17............	1.90	32.30	2.70	3.20	1.65
18............	1.85	33.30	2.80	3.30	1.70
19............	1.80	34.20	2.85	3.40	1.70
20............	1.75	35.00	2.90	3.50	1.75
21............	1.70	35.70	2.95	3.55	1.80
22............	1.65	36.30	3.00	3.60	1.80
23............	1.60	36.80	3.05	3.65	1.85
24............	1.55	37.20	3.10	3.70	1.90
25 and over	1.50	37.50	3.15	3.75	1.90

TABLE II.—CAPACITY CHARGE SCHEDULE FOR COMMERCIAL LIGHTING.

No. lamps demanded.	Per light per year.	Per year	Average monthly charge.	Monthly charge, winter, 8 months.	Monthly charge, summer, 4 months.
1............	$6.00	$6.00	$0.50	$0.60	$0.30
2............	4.00	8.00	.65	.80	.40
3............	3.00	9.00	.75	1.00	.50
4............	2.50	10.00	.85	1.10	.55
5............	2.25	11.20	.95	1.20	.60
6............	2.00	12.00	1.00	1.35	.70
7............	1.95	13.85	1.15	1.50	.75
8............	1.90	15.20	1.25	1.65	.85
9............	1.85	16.65	1.40	1.80	.90
10............	1.80	18.00	1.50	1.90	.95
11............	1.75	19.20	1.60	2.05	1.00
12............	1.70	20.40	1.70	2.15	1.05
13............	1.65	21.45	1.75	2.25	1.10
14............	1.60	22.40	1.85	2.35	1.15
15............	1.55	23.25	1.95	2.40	1.20
16............	1.50	24.00	2.00	2.45	1.30
17............	1.45	24.65	2.05	2.50	1.30
18............	1.40	25.20	2.10	2.55	1.30
19............	1.35	25.65	2.20	2.60	1.30
20............	1.30	26.25	2.25	2.65	1.30

For places open less than three nights per week take one-half of the tabulated contract charge and add 50 per cent to the meter rate.

It will be noted that in the tables the fixed annual charge is spread over the winter and summer seasons differently, the charge per month in the winter being twice that in the summer. This arrangement is made with a view to meeting the universal expectation of customers that summer bills shall be considerably less than those in the winter. In the case previously noted of 75,000 watt-hours consumption a year, the bills rendered would be approximately as follows:

	Summer.	Winter.
Capacity charge	$.75	$1.50
Current charge, 4000 watt-hours and 7500 watt-hours..	.20	.38
Total	$.95	$1.88

A customer cannot be made to do things without some inducement. The customer is generally looking for (1) a small demand, i. e., the use of a few lamps at one time; (2) a low current charge; (3) a liberal discount, more in summer than in winter; (4) a chance to use electric light exclusively. There are electric plants in this country selling current for street railway service at about four cents per car-mile, and about 1500 watt-hours are required at the switchboard per car-mile accounted for; that means about 2¾ cents per kilowatt-hour. This is simply an indication of what a plant might do in the electric light business if people could be induced to use the service long hours for both light and power. An equitable method of charging will lengthen the hours of use, smooth off the peak of the load curve and increase the all-day efficiency of the plant. The argument for block and factory lighting and municipal ownership does not make much headway against this system.

A demand fixed according to the schedule presented gives the customer the use of all current in excess of a certain number of lamp hours at the exceptionally low rate of one-fourth of a cent per lamp-hour. Thus:

	¼ cent for all over
5 lamp demand	400 hours per year
10 " "	350 " " "
15 " "	300 " " "
20 " "	250 " " "
25 " "	200 " " "

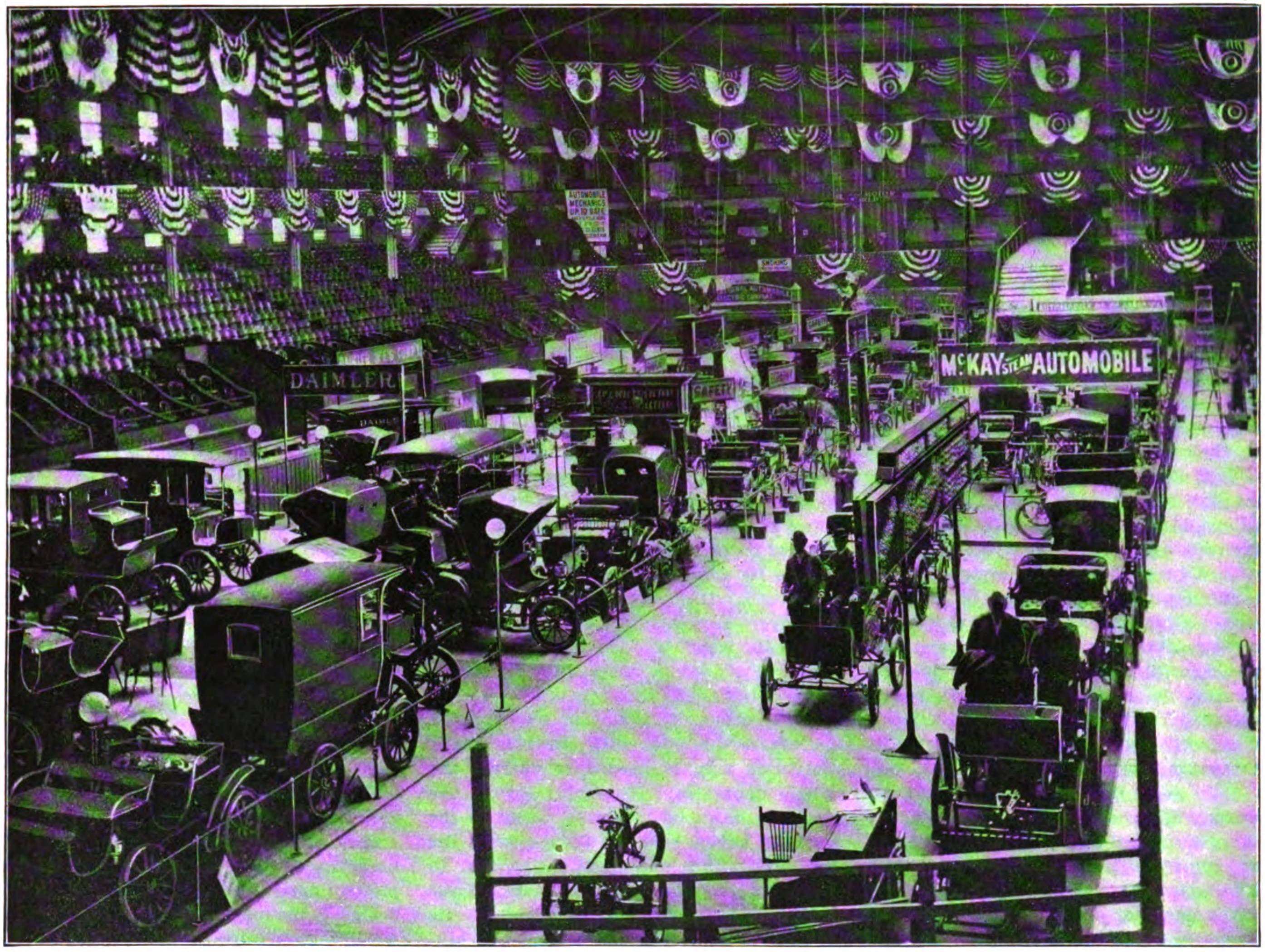
In order to obtain a low rate a 5-lamp demand must be used 400 hours per year, while a twenty-five light demand needs to be used only 200 hours per year.

With large consumption, independent of the demand, it is possible to obtain current for less than 6 cents per 1000 watt-hours. Those who want the service for appearance sake will be disappointed, but there is a class of customers it will not pay to try to carry. The contract is, in effect, that the customer leases a certain specific demand upon the plant, and is practically owner of the plant to that extent for the time being, without the troubles incident to the actual ownership and operation. It should be for a year payable monthly, less in summer than in winter, to terminate on removal or abandonment of premises for more than the unexpired term of the contract. It may be co-operative to the extent that the more there are who join in the plan, the less the contract charge may be made from year to year. Electric lighting may thus be taken out of the class of luxuries and placed on a level where everyone can not only afford to have the service at their disposal but use it as well.

There are those who will object to the proposed plan because they will be away for a certain part of the year, at the beach or mountains, or elsewhere, and it is a hardship for them to pay the contract charge when not using current. Do they object to paying house-rent or taxes on the same grounds? One cannot move the electric light plant around to accommodate its patrons. Interest, depreciation, taxes, etc., have to be paid just the same whether these people are away or not, and the plant is always "ready to serve" them.

THE AUTOMOBILE EXHIBITION.

The first annual exhibit of the Automobile Club of America, which was made at Madison Square Garden November 3 to 10, inclusive, seems to have been an unqualified success both technically and financially. The exhibits included practically all of the representative motor-driven vehicles of American make and also included several of foreign origin. Space limitations forbid anything like a detailed enumeration of the vehicles shown, but the accompanying illustration gives a very good idea of the general appearance of the exhibition space. The exhibit was unusually free from freaks of all kinds, the vehicles being conventional types driven by electricity, steam, and gasoline, and built for the most part along sound engineering lines.



GENERAL VIEW OF THE AUTOMOBILE EXHIBIT SPACE IN MADISON SQUARE GARDEN.

One of the vehicles which attracted particular attention was a little three-wheeled gasoline runabout built by the Knox Automobile Company, of Springfield, Mass. This vehicle was equipped with a 4-h.p. air-cooled gasoline engine regulated by a combination of variable compression and speed-changing gear. Another attractive vehicle was a Baker electric runabout for two persons, which weighed only 550 lbs. and was equipped with a ¾-h.p. electric motor chain-geared to the rear axle. A number of the small parts of this vehicle were made of a nickel-aluminum alloy in order to reduce the weight as far as possible. The battery was contained in two trays and located under the seat of the vehicle, leaving the rear of the body free. The runabout was said to have a radius of action of 20 miles.

The exhibition space was surrounded by a track, the geometrical form of which was an oval, and this was almost constantly occupied by vehicles in parade moving along at a speed of 8 to 10 miles an hour. This panoramic display was one of the most attractive features of the show. Among other interesting features were braking tests, obstacle races and hill-climbing demonstrations. For the latter a runway 200 ft. long and 8 ft. wide was built up on the roof of the Garden, in four sections of different grades; the smallest grade was said to be 20 per cent and the steepest 43½. Both the braking and obstacle contests held on the final night of the show were won by electric vehicles. The braking contest was won by a Riker vehicle, the distance being 14 ft. 6½ ins. in 6.4 seconds and 15 ft. 11 ins. in 6.4 seconds from speed estimated at over 10 miles an hour. A vehicle of the Baker Company won the obstacle contest in 24.8 and 30.4 seconds respectively.

The General Electric Company exhibited a most convenient outfit for charging the batteries of electrical vehicles. This outfit consisted of an electric "hydrant," which has been termed an "electrant," supplied with current from a suitable generating source. This electrant is provided with four receptacles, No. 1 giving a charging current of 20 amperes; No. 2 a charging current of 30 amperes; No. 3, 40 amperes, and No. 4, 50 amperes. A coin-in-the-slot mechanism controls the connections. In order to get a charge, all the operator has to do is to run up alongside the electrant, insert his charging plug in one of the four receptacles, and then drop a 25-cent piece in the slot; the result is a 2½ kilowatt-hour charge.

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LIFTING ELECTROMAGNETS.

BY E. B. CLARK.

The use of electrically energized lifting magnets on cranes, conveyors, and other hoists is a subject which has received far less attention than it deserves. Although, whenever electromagnets are so employed in practice they have excited much interest, their use has not extended nearly so far as it could with much advantage. This fact has been due to two reasons: (1) Mills and shops where bulky magnetic materials are handled have, until recently, not been thoroughly equipped with electric power. (2) Inasmuch as iron and steel products that are handled with power machinery are always heavy, large and powerful magnets must be employed, but there is practically no existing data dealing with the design and construction of such magnets that can be referred to in planning to build them.

In the early days of the study of magnetism, Sturgeon, Roberts, Joule and others succeeded in producing magnets of very considerable lifting power (from 2000 to 3000 pounds), but they were all excited by windings containing very few turns of comparatively large copper wire worked up to a very high temperature, and they were tested in laboratories under the most favorable circumstances. With such conditions they were enabled to get a high lifting power per pound of material in the magnet, but they did so at the sacrifice of certain other qualities that are all-important for magnets built for everyday rough use.

Magnets are valuable only where the material to be handled is magnetic, which practically means that it must be iron or steel, though there are special cases where other materials could be handled to advantage in iron receptacles. Another essential condition to make magnets especially useful is that the material handled shall be bulky, and also awkward to pick up in any other way. With these existing conditions making magnets advisable it is still not possible to use them to advantage unless the material to be handled can present some readily accessible smooth surface to which the magnet face can be presented easily. These conditions frequently are all met with, most often in rolling mills, boiler shops and locomotive repair shops, but also in factories making other products, awkward to handle, as, for instance, projectiles. Generally it is inadvisable to try to handle with a magnet such irregular shapes as car wheels, castings, etc., and much of the existing prejudice against this mode of handling may be attributed to unsuccessful attempts to make such applications.

In rolling mills, where nearly all of the magnets now in use are employed, they are used to convey unsheared plates from the straightening rolls or the "hot-bed" to the shears, to convey the sheared plates from the shears to the inspecting beds, thence to remove them to the stock piles, or to load them on cars, as the case may be. Here a magnet is peculiarly fitted for its work. A steel plate, especially as it comes from the rolls, is a decidedly awkward piece of material to take hold of. It is, perhaps, 40 ft. long, 8 ft. wide and ⅜ in. thick. It is heavy, flexible and generally hot. If it is carried on roller tables, the tables must be long, for the plate must be cooled some and marked out before it goes to the shears, which means that there is a lot of machinery to keep in repair. If it is carried on overhead traveling conveyors, it must be picked up by several pairs of hooks, which must be attached by hand at the cost of much labor and time. If it is carried on traveling conveyors supporting it from below, two hot-beds must be provided to enable marking out, and a complicated lot of machinery installed.

If, however, it is carried by overhead conveyors, equipped with electromagnets, only one man is needed to operate the whole apparatus. He simply lowers the magnets down on the plate, turns on the current, hoists, runs his plate over to the desired position, and opens the switch. In handling long plates at the shears a crane equipped with an electromagnet on its hook can be of great assistance. In taking the sheared plates away, to be piled in stock piles or to be loaded in cars, cranes with magnets can save a great deal of time and enable the work to be done with much economy of labor that cannot otherwise be effected. This is proven by the fact that in those mills so equipped a disabled magnet will necessitate putting on two or three more men for each crane, and even then will cut down the speed of shipment by 15 per cent to 30 per cent, according to the size and shape of plates.

The one great objection urged against magnets by those who are opposed to their use is that they are liable to drop plates or whatever they may be handling upon the heads of men passing underneath either by reason of the current failing or because the plate is too near the capacity of the magnet to make it hold securely. It is argued that there is always a chance of the current being cut off unexpectedly and that inasmuch as there is no way to tell absolutely whether a magnet will surely support a certain plate, there is always a chance of a large plate dropping off. Both of these contentions are, in the main, true, though by proper design of magnets and circuits the danger from both sources may be reduced to a minimum, but there is no need of handling plates in such a way as to endanger men's lives. Generally it is not necessary for men to get under plates at all, and in the few cases where it is, as for inspecting, guards may easily be arranged to protect against the remote possibility of a plate dropping. Besides, is it not a fact that men should keep from under bodies supported in any way on overhead carriers? Slings and hooks are just as liable to slip and break as are magnets to let go. As evidence on this point it is perhaps worth while to say that during several years' experience with magnets used as above described the writer has yet to know of the first accident caused by the unexpected dropping of a plate.

The amount of power consumed by an electromagnet, although generally so small as to be entirely unimportant, still is a point worthy of consideration. In every case it is almost altogether a question of design. Generally speaking, it may be said that the less a magnet weighs the less power will have to be expended per pound lifted. Also the less a magnet weighs the greater the ratio of lifting power to weight of magnet; in other words, the less the weight of the magnet the more each pound of it will lift. This follows from the fact that, roughly speaking, the lifting power of a magnet is a function of the square of its linear dimensions, while its weight is a function of the cube of its linear dimensions. Therefore the ratio of its lifting power to its weight is the ratio of the square to the cube of its linear dimensions, a ratio that decreases rapidly with increase of size of the magnet.

It is, of course, true, with the design of magnets, as with the design of any other piece of apparatus, that the most desirable design is the one that, while it will do the work satisfactorily, can be built for the least money. And it is also true, here as elsewhere, that the cost of operation and maintenance is just as important a part of the designer's problem as is the first cost of construction. Both of these points are involved in a decision of the proper winding for the coils, which depends largely upon the service to which the magnet is to be adapted. The higher the current density the greater will be the heating effect and the consequent loss of energy and liability to burn-out. On the other hand, the greater the current density the less copper need be used, which not only lessens the cost by reducing the amount of copper, but also by shortening the magnetic circuit and thereby using power at a higher efficiency. It is by obtaining a happy medium between these two considerations that a successful design can be produced, and the location of this medial point depends in any case upon the character of the service which is expected of the magnet. The less constantly it is to be used, and the shorter is each period of use, the higher may the current density be run.

In general we may say that the calculation of a magnetic circuit may be proceeded with exactly as can the calculation of an electric circuit. That is, given the amount of magnetism required, design the shortest (having least reluctance) magnetic path, which may be encircled by a winding sufficiently strong to drive the required magnetic flux through the figured reluctance of the circuit.

It is a comparatively easy matter to arrive at the required amount of magnetic flux in any special case, because it is useless to run steel or wrought iron very much above the point at which the traction is about 150 lbs. per square inch, though it is quite possible to get it up to a point where the traction will be 200 lbs. per square inch if there is any special reason why such a point should be reached. But having determined upon the total number of magnetic lines and assumed a magnetic circuit, it is then not nearly so easy to estimate the reluctance of that circuit. Not only is the permeability of the materials rather an uncertain quantity and the accuracy of the mechanical work of the joints in a certain measure indeterminate, but, far more important, the width of the airgap between the pole-face and its keeper is exceedingly difficult of prediction. It is this airgap, too, which forms the major part of the reluctance of the circuit. It will be found that if this is made large, say ¼ in., such an enormous magneto motive force will have to be employed to get a useful traction that the copper winding will be excessive. And yet in practice it would require a comparatively slight obstruction to hold the magnet ¼ in. away from the metal. It is this fact that makes the use of a magnet on any irregular shape difficult, for unless it is possible to lift the weight with far less magnetism than the maximum, an irregular shape cannot be picked up.

In arranging this magnetic circuit, the usual precautions against leakage must be observed, though other considerations governing the form of the magnet are so important as to make leakage a secondary point. It is a very difficult question to handle, and the limit of error is so great, owing to variable airgap, that the only practical method of dealing with it is to use the least objectionable form and then to make liberal allowance for leakage. The form of the magnetic circuit has great influence upon its action and varies greatly with the work to be done. The magnet which will exert the greatest power in adhesion is the one having the shortest and most compact circuit, but this is not always the most desirable form for other reasons. In picking up plates from a pile it is sometimes desirable that only one shall be taken at a time, and sometimes preferable that a number shall be taken at once to expedite the work. Different forms of magnets are adapted to each case. It is frequently required to handle just one shape or one thickness of plate all the time, while in other cases a large range of sizes must be accommodated. A certain form is best adapted to each class of work. But whatever the shape of the magnet, it must be mechanically substantial. The coils must be thoroughly protected from injury and must be provided with the best of insulation, for the magnet will receive hard usage. The points where the leads enter the case must be so protected as to admit of a broken lead being repaired easily, without taking the coils out. The whole magnet must be arranged to enable repairs to be made without trouble, for the work is rough and will damage any construction in time.

The form which upon first thought seems most suitable, both from a magnetic and from a mechanical standpoint, is a simple horseshoe with one limb developed to form an envelope for the rest of the magnet, as shown in Fig. 1. But further consideration and actual trial show this to be a poor form for such work as plate handling, on account of the round shape of the pole-face and on account of the excessive leakage from pole to pole. A single large magnet is also undesirable, where a large area of effective surface must be provided, from the weight considerations previously pointed out. A group of small magnets of this general shape would be better, but the writer does not believe this form to be adapted to the work, notwithstanding the fact that it has long been a favorite shape and that some of the early inventions were based upon it.

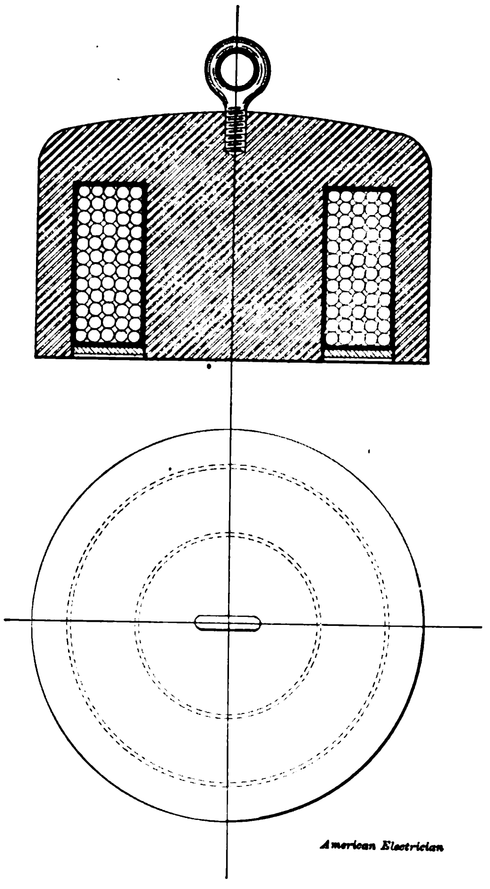
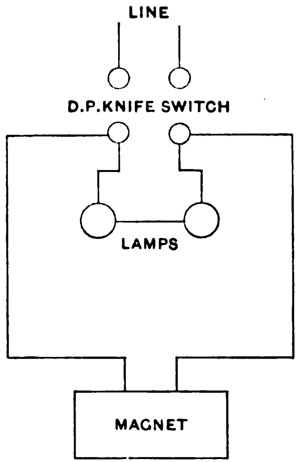

American Electrician

FIG. 1.—LIFTING MAGNET.

The round pole-face does not offer sufficient resistance to the tendency of plates to bend and tear themselves away from the magnet. This tendency is the most serious one for the designer to combat in plate-handling, which is by far the most important use of magnets to date. A round magnet which will lift, on a straight pull, 10,000 lbs. easily, will refuse to pick up a long thin plate weighing 1000 lbs. The magnet should present a straight line instead of the arc of a circle at the bend of the plate. For plate work a group of rectangular poles seems best in practice. Different dispositions of the same amount of material in a magnet produce surprisingly different results.



American Electrician

FIG. 2.—CIRCUIT CONNECTIONS.

Frequently it is desired to regulate the strength of a magnet; that is, to cause it at times to pick up several objects, and at others fewer or only one. It is possible to do this by means of a rheostat in series with the winding, but such a means gives much trouble in adjusting and is apt to cause dropping. A better plan is have the operator drop off any superfluous material by opening the switch for an instant and quickly closing it again. As unlikely as it may appear, it is still nevertheless true that it is an easy matter for the operator in this way to regulate very easily and very simply exactly the load which he wishes the magnet to carry, and then he can always have the maximum lifting power of the magnet available.

One trouble that may be met with is flashing, upon the opening of the switch, due to the natural kick produced by the opening of a circuit possessing high self-induction, and also to the current induced when gravity tears the keeper from the magnet face. The self-induction may be reduced by proper arrangement of coils, but it is best to adopt the following means of avoiding the evil influences of flashing at the switch, especially when several magnets are energized in multiple as when handling long plates. Connect a circuit of incandescent lamps or other non-inductive resistance in multiple with the magnet on the dead side of the switch, as shown in Fig. 2. The total normal voltage of the lamps should be about 50 per cent more than the voltage across the line, and the normal current capacity of the lamp circuit about 50 per cent of the current absorbed by the magnet. That is, if the magnet takes about 3 amperes at 240 volts, use 3 lamps each 50 candle-power at 120 volts.

By means of this precaution the puncturing of the insulation due to inductive action will be prevented. It is interesting to note the lamps gradually dim when the switch is opened and then, when the piece on the magnet finally drops, to see the lamps light up again for an instant as the induced current passes through them. Of course the lamps are placed at the switch near the operator when the magnet is in an unfavorable location. For regulating the strength of the magnet to provide for cases where an unusually large air-gap demands excessive magnetization to secure adequate lifting power, the writer has found a series-parallel connection of coils to be a decided advantage.

If the magnet is suspended on a crane hook which travels through much vertical distance a reel must be arranged to coil up the lead wires and let them out again as the magnet moves up and down. Trolley wires must be provided to convey the current to the magnet.

The current consumption of a magnet depends upon the winding of the coils, but roughly speaking, a magnet for handling ordinary sheared plates, having a capacity of, say 3000 lbs., on this work should operate easily and satisfactorily on 1000 watts. This same magnet under favorable conditions will lift 10,000 lbs. with the same power consumption, but to do this the keeper must be accurately fitted to the pole faces.

* * *

ELECTRICITY IN FARMING.

BY GEO. E. WALSH.

In the application of electricity to farming there has been in recent years a revolution of methods, indicating that agriculture is keeping pace with other pursuits in the matter of up-to-date development. The size and completeness of farming machines have steadily increased since the middle of the present century. The very latest type of machines for harvesting the grain and hay crops will be put in full operation in the wheat fields of California this season. These power-driven harvesters have cutters 26 ft. wide, and as they move across the field they cut the wheat, thrash it out, clean it, and then sack it ready for the market. One harvester can gather the crop of 75 acres in a single day, automatically gathering and cleaning the crop for market. These immense harvesters are drawn across the fields by traction engines of 50 horse-power, having driving wheels 60 ins. in diameter with a tread 60 ins. in width. The same engines drag the plows and harrows and feeders in the early spring. One of them can draw over the field sixteen 10-in. plows, four 6-ft. harrows and a press drill to match. The outfit will thus plow, harrow and seed from 50 to 75 acres in a day by a single operation.

The operation of these big engines by electricity is one of the latest phases of the subject. On the mammoth Western farms, where electricity can be generated cheaply, this power takes the place of nearly all others. Not all farms are so fortunately situated that an electric plant can be economically installed. Where there is a stream of water running through the farm it is a comparatively easy matter to solve the problem. On several of the largest Western farms, where all the power necessary to work the farm is thus available, electric plants have been placed. The size and flow of such streams are often altogether out of all proportion to the amount of work they do, and in the dry summer season the beds of the streams are all but dried up. The water is stored up, however, during the wet season in huge reservoirs so that it can be utilized when needed. In some of the irrigation districts the power of this stored water is sufficient to supply all the power needed on the farms, besides all that is required for watering the growing crops. At present the vast systems of reservoirs where the water is stored for irrigation represent sufficient stored power to generate an immense amount of electrical energy. The power of such rivers as the Missouri, Colorado, Rio Grande and other large Western streams has been measured chiefly heretofore from an irrigation pont of view. Nearly or quite $50,000,000 are spent annually in irrigation works in the West, and this vast outlay merely collects, stores and distributes the water for farming purposes. The power thus wasted is enormous. The water stored for irrigation purposes in the state of Colorado would be sufficient to turn nearly all the wheels of commerce of that state if it were turned into electrical power before being distributed to the farmers.

In some respects agriculture abroad has been influenced more by electricity than in this country. A short time ago the U. S. Consul at Magdeburg, Germany, described the operation of an electric farm near one of the cities that foreshadowed what has since been realized in many parts of this country. The motive power of this farm was furnished by a comparatively small brook, whose waters were stored in a reservoir. The volume of the stream changes according to the season, but even in the driest weather there is sufficient storage capacity to furnish 16 horse-power, and this runs up as high as 24 horse-power in the wet season. The turbine wheel drives a Schuckert dynamo, which develops all the power needed. Wires are strung on poles and carried to different parts of the farm, and the current furnishes light, heat and power. There are two electric motors on the farm to drive the pumps for the stables, a straw and hay cutter, a grindstone, a turning lathe, and a large band saw capable of cutting up huge logs. There is a larger motor for driving heavier machinery, such as a threshing machine. This machine can be located anywhere in the field or in the barn, and connected up with the supply circuit through flexible leads.

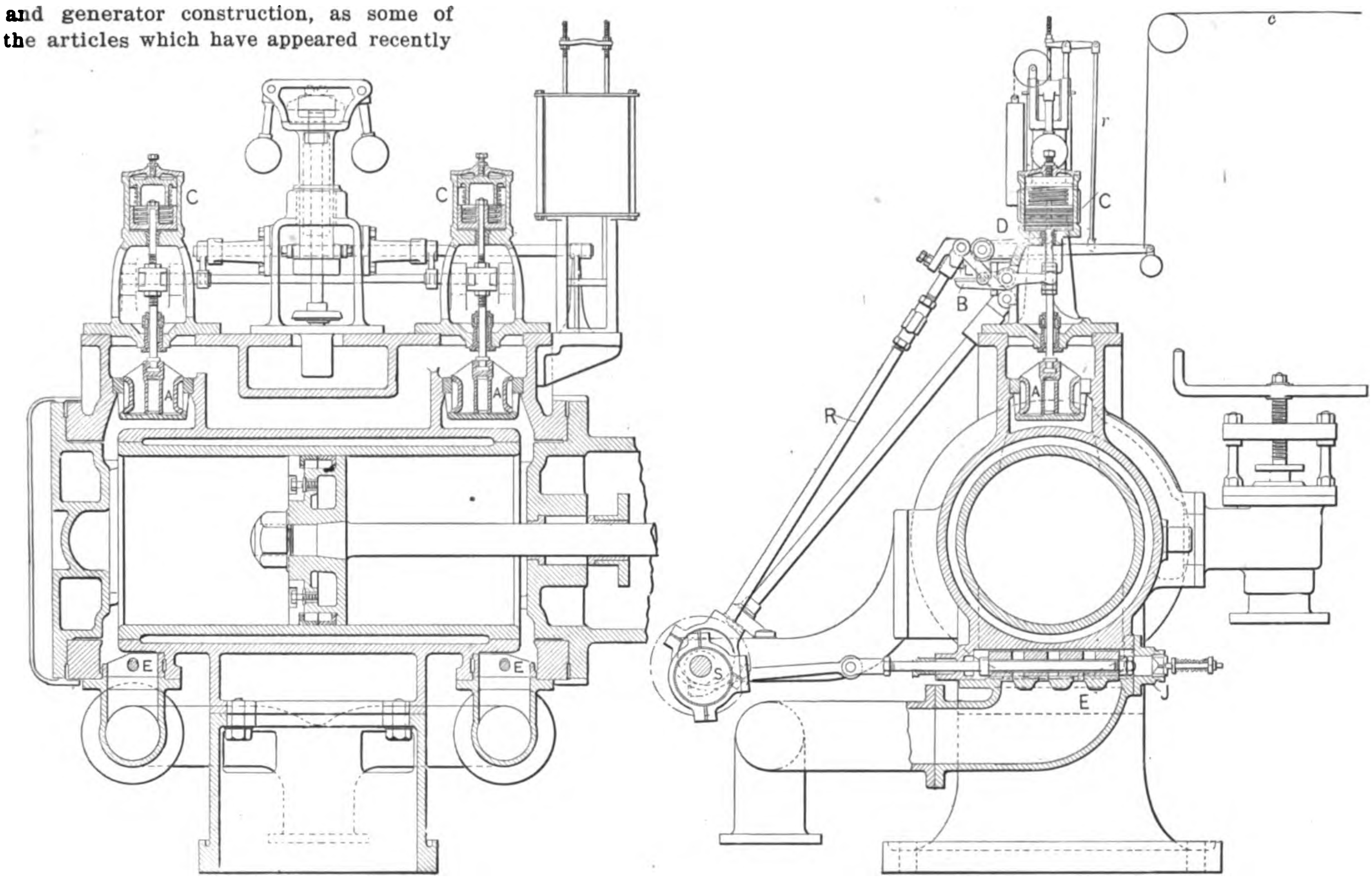
In Germany electric plows are drawn across the field by a cable which is hauled in by electric motors, one on either side of the field. A single electric plow cuts five or six furrows, and each time it arrives at one side of the field it is turned around and the opposite motor winds up the cable to drag it back. The motors are moved an equal distance after each "round trip" of the plow, so that the furrows are as straight and true as if cut out by a line. There are smaller plows cutting only one or two furrows, but the larger ones have been found more economical in the end. Another electric plow employs a long stationary cable fastened to the earth on either side of the field by a movable anchor. Along the cable travels the plow, which is equipped with an electric motor that propels it. When at the end of a furrow the cables have to be moved, and the return trip is then made. These electric plows move much faster than the old horse plows. Harrows, seeders and cultivators are made to be attached to the cables in the same way as the plows, and it is a matter of only a short time to make the change.

Nearly all field machines have now been built for electric propulsion, and automobile hay-rakes, reapers and fertilizer spreaders are all easily attached to the cables. Corn huskers, shellers, feed mills and hay-choppers are operated by electricity, and even the hay is loaded in the field and unloaded at the barn by electric machinery. By means of overhead cables the power can be delivered to any part of the field on short notice. There is always plenty of cable for instant use, and when a distant field will no longer require any work for six months or a year the wires can be taken down and carried to other places.

In this connection something should be said of the automatic tree cutter, which was first operated in Europe and has proved so successful in cutting down the great trees in Galicia. Tree cutting is a part of the farmer's work, and many virgin farms have been cleared of trees by the electric feller. This machine, however, is really built more in the interests of the lumberman than the farmer. A motor and saw are mounted on a two-wheel carriage for facility of transportation to any part of the field or woods. When drawn close up to a tree it is securely fastened to it by clamps and chains. From the body of the carriage extends the cutting apparatus, consisting of a revolving saw that cuts around the tree on all sides and weakens it so that it can be readily pulled down by ropes after the electric motor is removed. It takes only a few seconds for the saw to cut down a tree after it is once put in operation, and a forest can be denuded of trees in half the space of time required for hand-operated saws or axes.

With farming machinery invented for such work, the problem of applying electric power to agriculture is reduced practically to the question of generating the primal power through the use of stored irrigation water. So closely is this matter connected with that of engineering irrigation that the two should be considered together. If it pays to spend millions of dollars in irrigating the western farming lands it will doubly pay to utilize the power of the stored water for generating electricity to operate all the farm machinery and tools.

An English Engine for Lighting Service.



FIGS. 1 AND 2.—VALVE AND VALVE-GEAR DETAILS OF THE ROBEY ENGINE.

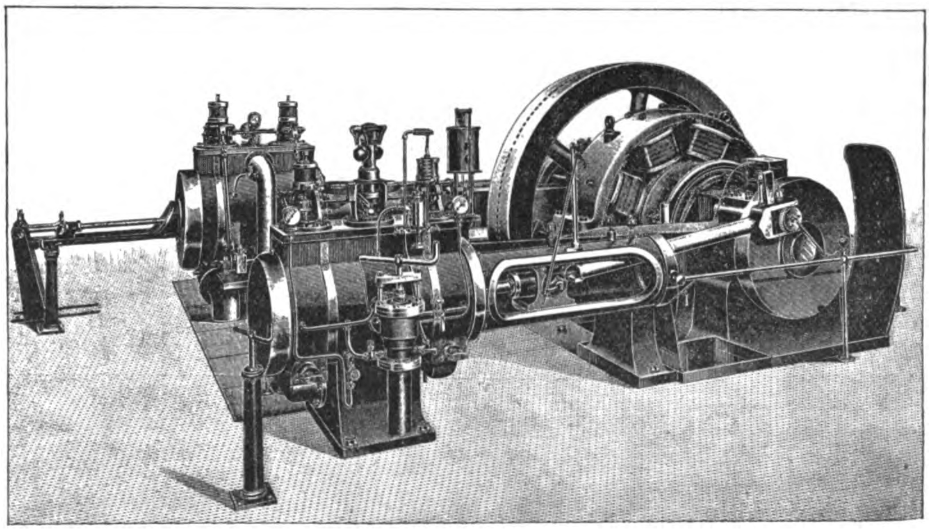


FIG. 3.—ROBEY CROSS-COMPOUND ELECTRIC LIGHT ENGINE.

The Paris Exposition, just closed, afforded an excellent opportunity for the study of European practice in both engine and generator construction, as some of the articles which have appeared recently in these columns indicate. Prominent among the examples of engines was a cross-compound engine, built by Messrs. Robey & Co., Ltd., of Lincoln and London, England, and designed especially for electric-light service; the generator is mounted between the low and high pressure cranks of the engine, as shown. An interesting feature of this engine is the Richardson-Rowland patented trip gear, which is illustrated in detail in Figs. 1 and 2. The admission valves, AA, are of the double-beat lifting type, and the exhaust valve, E, is of the grid-iron slide pattern. Referring to Fig. 2, the eccentric rod, R, is arranged to lift the admission valve, A, through the medium of a latch, L, and a rocker arm, B. Owing to the difference in the arcs described by the end of the eccentric rod, R, and the end of the rocker arm, B, the latch, L, slips off the end of the rod, B, allowing the valve to drop under the influence of the coil springs in the housing, C, which also contains a dashpot.

The variation in the cut-off is affected by the movement of a bell-crank lever D, the long arm of which is raised and lowered by an ordinary fly-ball governor through the medium of the rod, R; the short arm of the bell-crank, D, is attached by means of a link to the fulcrum of the rocker arm, B, and is adapted to move this fulcrum horizontally one way or other, according to the direction in which the governor moves the horizontal arm of the bell-crank. It is obvious that as the governor draws up this horizontal arm, the fulcrum of the rocker arm, B, is carried inward and consequently the latch, L, slips off the end of the arm, B, at an earlier point in its travel. A cord, c, is led upward from the extremity of the horizontal arm of the bell crank, D, to any desired point in the station and furnishes a means of shutting off steam from the engine instantly by pulling the cord and raising the bell crank arm to its maximum height. This withdraws the rocker arm, B, entirely from the reach of the latch, L, so that the admission valve, A, remains closed. The grid-iron exhaust valve, E, is operated by a separate eccentric, as shown, and is provided with a balance plate. Both of the eccentrics are mounted on a secondary shaft, S, which reminds one strongly of gas-engine practice; this shaft also drives the fly-ball governor. It is stated that the valve-gear is so sensitive and easy of operation that the secondary shaft, S, of a very large engine can be readily turned over by hand.

THE USE OF THE STEAM CALORIMETER.

BY A. F. NAGLE.

In the November issue of this paper the writer gave a historical resume of the evolutionary development of the steam calorimeter. The purpose of the present article is to give a more detailed description of the practical use of the instrument, and in doing this the article will be restricted to a discussion of the latest form of the Barrus calorimeter, shown by Fig. 2. For the purpose of comparison the older form is reproduced from the last issue in Fig. 1. Before proceeding with the subject matter, however, the writer desires to call attention to an error in the previous article in the numerical example illustrating the application of Prof. Peabody's formula; the boiler pressure of 150 lbs. was stated to be gauge pressure, whereas it should have been referred to as absolute pressure, the gauge pressure being 135.3 lbs. The pressure of 3.3 lbs. given for the calorimeter was gauge pressure.

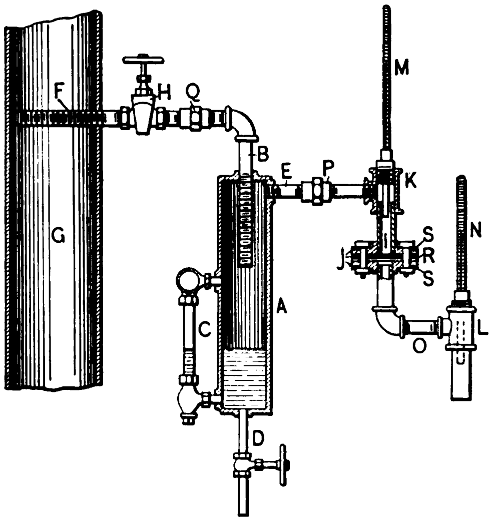


FIG. 1.—OLDER FORM OF BARRUS CALORIMETER.

If the reader will carefully compare the two forms of the Barrus calorimeter he will find a decided improvement in the latest design. Not only is the apparatus of neater and simpler mechanical design, but it is a great improvement to be able to weigh in an open pan the water (if there be any) deposited in the separator, for this water is now of the temperature corresponding to the atmospheric pressure, whereas formerly (and in other instruments) the water deposited in the separator is at the temperature of the steam to be tested.

In the latest instrument, Fig. 2, the throttling or wire-drawing feature is first called into use to its fullest extent, and if there be more moisture in the steam than can be absorbed by the superheat generated by the wire-drawing operation, it is deposited at atmospheric pressure in the separator. It will be observed that there are two thermometers, one marked M, to indicate the temperature (which is also an indication of the pressure, provided it is not superheated) of the steam to be tested, and the other, marked N, which gives the temperature of the steam after it is wire-drawn through the small aperture; from the indications of this latter thermometer the moisture is calculated.

As the opening from the separator into the atmosphere is very large in comparison with the small orifice, the pressure therein can be safely taken to be that of the atmosphere. As long as the temperature of thermometer, N, is above 212°, there will be no deposit of water in the separator. Let us consider the operation of the instrument when N is at or above 212°. The fundamental formula for the quality of the steam is

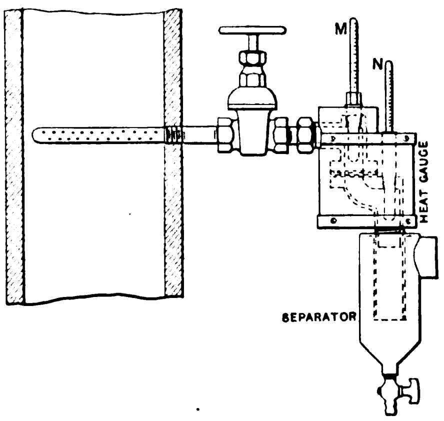


FIG. 2.—LATEST FORM OF BARRUS CALORIMETER.

$$X = \frac{H_1 - q + .48\,(t_s - t_1)}{r} \quad \ldots\ldots\ldots (A)$$

where X = quality of steam; dry steam = 1;

1 — X = moisture;

r = heat of vaporization (latent heat) of the steam to be tested.

q = heat of liquid (water) corresponding to r.

H_1 = total heat of steam in the calorimeter, which at atmospheric pressure = 1146.6 B. T. U.

t_1 = temperature corresponding to H_1, and which we now take to be = 212°.

t_s = temperature of the superheated steam in the calorimeter, by the thermometer, N.

0.48 = the specific heat of steam at constant pressure.

With the constant value of 1146.6 for H_1 and 212° for t_1 in equation (A), there is no reason why the formula should not be written

$$X = \frac{1146.6 - q + 0.48\ t_s - 0.48 \times 212}{r}$$

which reduces to

$$X = \frac{1044.84 - q + 0.48\ t_s}{r} \quad \ldots\ldots\ldots\ldots (B)$$

which simple equation may be safely used in connection with this calorimeter.

It will be interesting to know the results of two extreme conditions of the instrument, one when the steam is dry, and the other when the limit of the wire-drawing feature is reached; that is, when the thermometer, N, indicates 212°. In the first case we make X = 1 in equation (A), and solve for t_s; and in the second case we take t_s at 212°, and solve for X. Examples: In the first case, assume the thermometer M to read 350°, and N to show 212°. We find in Peabody's steam tables r = 867.3; q = 321.4; and making proper substitutions, we have

$$1 = \frac{1146.6 - 321.4 + 0.48\ (t_s - 212)}{867.3}, \text{ or}$$

$$867.3 = 825.2 + 0.48\ t_s - 101.76.$$

Hence, 0.48 t_s = 143.86, and t_s = 300°.

On the other hand, solving for X when t_s = 212°, other values remaining as before, we have

$$X = \frac{1146.6 - 321.4 + 0.48\ (212 - 212)}{867.3} = \frac{825.2}{867.3} = 0.95$$

and 1 — X = 0.05 or 5 per cent.

TABLE I.

1. Temp. of M.	2. Absolute pressure corresponding to M.	3. Temp. of N when X = 1.	4. (1 — X) × 100 when N = 212°. Per cent.	5. Correction of column 3 for radiation.	6. Per cent loss due to radiation in instrument.	7. Pounds of steam discharg'd per hr. 3/32-in. orifice.
Fahr.		Fahr.		Fahr.		
280	49.3	256	2.3	250	0.25	17.5
290	57.7	262	2.6	256	.30	20.5
300	67.2	268	3.0	262	.34	23.86
310	77.9	274	3.4	268	.35	27.65
320	90.0	280	3.7	274	.36	31.93
330	103.	287	4.0	280	.38	36.71
340	118.	293	4.4	286	.40	42.
350	135.	300	4.9	292	.43	47.92
360	153.	306	5.3	298	.45	54.42
370	173.	312	5.7	304	.47	61.63
380	196.	318	6.1	310	.49	69.58
390	220.	325	6.5	317	.49	78.24
400	247.	331	6.9	323	.49	87.75

In column 3 of Table I will be found theoretical values of t_s, and in column 4 theoretical values of 1 — X for different values of M. These values, however, would be absolutely correct only if there were no condensation in the instrument itself, or in its connecting pipes. Even with short connections, as shown in the engraving, and well-covered pipes, there is some loss of heat; consequently, the indications of the thermometer, N, will be below the figures given in column 3. Mr. Barrus has found the discrepancy to be from 6° to 8°, and the corrected values based on his experience are given in column 5. This corrected value is founded upon the assumption that when steam is not in motion, and in the presence of water, it is dry; hence, at any time when it is known that no steam is flowing in the pipe, corrected values for this calorimeter may be obtained by reading the thermometers, M and N, the difference between the reading of N and the theoretical temperature given in column 3 is to be attributed to radiation. Let us make a calculation of what this amounts to. Referring to formula (A) and using the same values as before, when the thermometer, M, stands at 350°, the table shows that for dry steam the thermometer, N, should indicate 300°, but if instead it stands at 292° the equation becomes

$$X = \frac{1146.6 - 321.4 + .48\,(292 - 212)}{867.3}$$

$$X = .9957$$

$$1 - X = .0.0043, \text{ or } 0.43 \text{ of 1 per cent.}$$

These values have been worked out for different steam temperatures, and are given in column 6 of Table I. It will be seen from this that all extreme refinements as to the exactness of tests for moisture in steam must be regarded with much doubt, as the instrument produces from ¼ to ½ of 1 per cent. of moisture within itself.

In order that the reader may thoroughly understand the use of this wire-drawing feature of the calorimeter, another illustration may be advisable. Assume the thermometer, M, to indicate 340°, which corresponds to 118.3 lbs. of absolute pressure; and that the thermometer, N, indicates 235°. In this case the other values in formula (A) will be, $r = 874.7$; $q = 310.9$; and the substitutions make the formula read:

$$X = \frac{1146.6 - 310.9 + .48\,(235 - 212)}{874.7} = 0.968,$$

and $1 - X = 0.032$, or 3.2 per cent.

As, however, there is a loss of 0.4 of 1 per cent within the instrument itself at this pressure, the moisture in the steam in the pipe would be 2.8 per cent. The same result will be obtained if we add 7° to the reading of thermometer, N, making it 242° instead of 235, in the equation given.

I wish to impress upon the reader the fact that unless correction be made for the loss of heat in the instrument his results will not be reliable within nearly ½ of 1 per cent. He can ascertain for himself what this correction should be by finding the variation of thermometer N from the values given in column 3 of Table I, corresponding to the different temperatures and pressures given in columns 1 and 2 at any time when the steam is not moving in the pipe from which steam is taken.

Possibly it may not be clear to the reader why steam is superheated when wire-drawn, or reduced to a lower pressure without doing work. If we take the total heat in steam, say of 360° temperature, or 153 lbs. absolute pressure at 1191.7 B. T. U., and the total heat of steam at 212°, or atmospheric pressure, at 1146.6 B. T. U., there is a difference of 45.1 B. T. U. between the two conditions of the steam. What becomes of this heat? It must heat the steam itself, and as it requires 0.48 B. T. U. (its specific heat) to raise the temperature of one pound of steam 1°,

$$\frac{45.1}{0.48} = 94°$$

must be added to the 212° temperature of steam at atmospheric pressure, making its temperature 306°. This figure is verified in Table I, column 3.

There are numerous so-called "short-cuts," or tables, given by the manufacturers of calorimeters which may simplify the calculations here pointed out, but the writer has thought it preferable that the reader should understand what he is doing and make his own calculations.

THE SEPARATOR ATTACHMENT.

If the moisture exceeds the amount which can be absorbed by the wire-drawing or superheating part of the apparatus the excess will be deposited in the separator vessel. It will be observed that no quantitative measurements had to be taken with the wire-drawing instrument; only two thermometers were required. It is a simple problem to ascertain the quantity of water deposited in the separator, compared with the entire amount of steam passing through the calorimeter. The water in the separator should be allowed to accumulate for an observed length of time and then be weighed in an open pan and reduced to its equivalent quantity per hour. Mr. Barrus has found that the instrument itself will condense about 0.13 lb. of steam per hour, hence this amount must be subtracted from the weight of the water in the separator in order to ascertain the correct amount attributable to the steam being tested.

To ascertain the total quantity of steam passing through the calorimeter, the reader can himself condense it in a vessel filled with cold water and weigh it; or for all practical purposes he can rely upon Napier's formula, $w = \frac{P \times A}{70}$, in which

w = pounds of water discharged per second.

P = steam pressure, absolute.

A = area of orifice in square inches, which in the Barrus instrument is 0.0069 square in., the diameter being 3-32 in.

70 = A constant, applicable when discharging into the atmosphere under a pressure not less than about 26 lbs. absolute.

Modifying this formula to obtain pounds of water (W) per hour we have:

$$W = \frac{P \times .0069 \times 60 \times 60}{70} = P \times 0.355.$$

The values of W for different temperatures and absolute pressures are given in column 7 of Table I. To illustrate: Assume the indication of the thermometer, M, to be as before, 350 degrees, corresponding to 135 lbs. absolute pressure, and that 2.3 lbs. of water per hour have accumulated in the separator. As about 0.13 lb. of this is due to the cooling effect of the instrument itself, only 2.17 lbs. are due to the steam to be tested. From column 7 of the table we find that the entire amount of steam passing through the instrument per hour is 47.92 lbs.; hence the percentage of separator deposit is

$$\frac{2.17 \times 100}{47.92} = 4.53 \text{ per cent.}$$

Inasmuch as the superheating portion of the instrument must have worked at its full capacity before any water could be deposited in the separator, we can find from columns 4 and 6 of the table what this is. For M = 350°, this is given as 4.9 per cent, but as 0.43 per cent of this is due to radiation of the instrument itself, there remains 4.47 per cent due to the steam or a total of 9 per cent for the entire calorimeter.

The writer has given in as simple and as plain language as possible the principles upon which calorimeter measurements are founded, and careful study of these should enable the intelligent operating engineer to make his own calorimeter tests. But accurate tests, like all other good work, require experience to make perfect, and the reader must realize the importance of using the instrument for long enough periods to obtain results that repeat themselves and appear consistent. The writer of instructions cannot enable the reader of them to acquire expertness in making scientific tests, nor can the reader fully qualify himself by merely reading; but after obtaining a knowledge of the principles of operation, with intelligence and persistence any one should be able ultimately to make correct calorimeter tests.

Only the Barrus calorimeter has been discussed because the writer believes it to be a reliable instrument if carefully handled. There are other instruments in the market, and it is by no means intended either by insinuation or implication to convey the idea that they are not as reliable as the Barrus. With the explanations given in these articles on the subject of steam calorimeters, the intelligent engineer should be able to use any instrument in the market. The writer is indebted for considerable data, as well as the illustrations presented in these articles, to the Transactions of the American Society of Mechanical Engineers.

SERIES WINDINGS ON COMPOUND DYNAMOS AND THEIR ADJUSTMENT.

BY ALTON D. ADAMS.

The primary object of equalizing cables is to put the series coils in multiple with each other, and these cables with their connections should therefore be chosen so that their resistance is a small proportion of the resistance in the coils they are to connect. A result of using too small cables or poor contacts may be a strong tendency on the part of some dynamos to carry all of the load, or the reversal of current through some of the coils that so weakens the magnets as to give one or more armatures a dangerous motor speed when they fall below the bus-bar voltage. Satisfactory parallel operation of compound-wound dynamos requires a uniform drop of pressure in all of the series coils at full load, and also that the compounding effect of each series coil be the same as that of every other. The drop of potential in a series coil at full load can be readily noted with a voltmeter graduated to tenths or finer and the compounding effect on a dynamo may be noted with a good voltmeter reading at least to single volts, when the load is changed from zero to full current capacity, with constant speed.

If the series coil of one dynamo has the correct resistance, so that the same drop of potential occurs in it at full load as in the series coils of the other dynamos, but the compounding effect in the one dynamo does not correspond with that of the other dynamos, it may be possible to help matters by a change of speed. If the compounding effect is too small, an increase of speed will make it larger; if too large, a drop in the speed will decrease it. This is due to changes that must be made in the magnetizing power of the shunt winding by the rheostat in order to hold the no-load voltage at the proper point. Where the drop of volts in a series coil is too small at full load, but its compounding effect is correct, the trouble is easily remedied by a resistance in series with the coil to increase the loss of pressure. If the drop in the series coil at full load is too great, but the compounding effect is correct, the difficulty cannot be remedied, except by a change in the structure of the coil.

When the full-load drop in a series coil is too great and the compounding effect is also too great and to the same extent, no change in the coil is necessary for multiple operation, since the reduction of pressure between the coil terminals will only allow enough current through it to give the proper magnetizing action. The use of shunts on the series coils of dynamos operating in multiple can only serve to reduce the volts across the terminals of all of the coils and consequently the compounding effect of all the coils, to the same extent, if the equalizer system is effective.

If two or more dynamos, each compounded for constant pressure when operated separately, have their series coils permanently connected in multiple, none of these dynamos can deliver current at constant voltage to the system, unless all of the dynamos so connected are in operation. This statement assumes that the resistances of the series coils vary inversely as the capacities of the dynamos. The smaller the per cent of the total dynamo capacity in operation at any time, the poorer will be the regulation. Similarly, if dynamos that are over-compounded for a certain rise of potential at full load, are operated with the series coils connected in parallel by a permanent equalizer, the predetermined compounding effect will be lost except when all of the dynamos are in use. At other times the dynamos actually operating may deliver increasing currents at either rising or falling pressures, depending on the number of dynamos in use.

About as much automatic regulation is thus to be had with compound-wound dynamos having their series coils permanently connected, as is obtained from plain shunt machines. Compound-wound dynamos with series coils whose resistances vary inversely as the dynamo capacities, and proportioned for constant terminal e.m.f., or for a uniform rise of e.m.f. with increasing load, will give the predetermined potentials when operated with series coils and armatures independently in multiple, if only the series coils of active dynamos are connected and the load is divided between the several armatures according to their capacities.

Where over-compounded dynamos are used on a lighting or power system the rise in volts at the dynamo terminals from no load to full load is usually intended to compensate for drop in the lines. The drop in the lines obviously varies directly with the current transmitted, being one-half of the total drop for one-half of the total current, and so on. A single dynamo may be over-compounded for any desired drop on its line, and the rise of volts at the dynamo terminals will correspond practically with the volts last in the line for any increase of load. Where, however, over-compounded dynamos operate in multiple, it is impracticable to have the line loss and the volts of increased e.m.f. at dynamo terminals correspond during more than a small part of the time. If each dynamo is designed to increase its terminal e.m.f. in the same ratio to any increase in its load that the drop in the line bears to the load on the line, the rise of voltage at the dynamo terminals will always be less than the loss on the line, unless the capacity of the dynamos in operation is just equal to the load for which the maximum line loss is figured.

Accurate rise of station pressure to compensate for line-loss may be obtained by means of a suitable booster generator, passing the entire current for which the line drop is to be compensated. Such a booster will add the correct e.m.f. for the line loss, whatever the relation between the station output and the total dynamo capacity. If the different feeders from a station have each heavy loads and quite different losses of pressure in them, a separate booster may well be employed for each. With these boosters much better results as to pressure regulation may be had than are now common on electric railway systems using either compound-wound or shunt-wound dynamos.

Abstracts from Foreign Contemporaries

Constant-Potential Direct-Current Converter.—In a recent issue of the London "Electrical Review" F. W. Davies describes an apparently new device for obtaining a constant potential at all loads on a direct-current converter. As the load increases, the ratio of transformation is varied by means of a peculiar arrangement of the armature winding used in conjunction with a special compensating winding on the field magnet. Each pole of the field magnet is provided with a slot in which the compensating coil is wound, as shown in Fig. 1. These coils are connected in series with the secondary circuit, and connected so as to assist the main magnet winding; their function is to strengthen the flux in the magnet pole on one side of the slot and to weaken it on the other side. The armature is shown in Fig. 2, where, for the sake of clearness, only two armature coils, one primary and one secondary are shown. The primary coil, P, is wound with the usual pitch, great enough to enclose the whole armature flux when the coil is in the neutral position. The secondary coil, S, is chord-wound with a pitch just great enough to enclose the lines of force which pass through the compensating coil but does not allow the coil to enclose any more than these; the angular pitch of the coil must, therefore, be approximately the same as the angle indicated in Fig. 1. At no load, when there is no current in the compensating field coils, the lines of force which are embraced by these coils are cut by both the primary and secondary armature windings, but the remainder are useless as far as the production of e.m.f. in the secondary winding is concerned. This makes the ratio of secondary primary volts less than it otherwise would be. When the load comes on, the compensating coils begin to divert some of the lines from the small polar horn and drive them through the polar area enclosed by the compensating coils, the total flux remaining practically con-

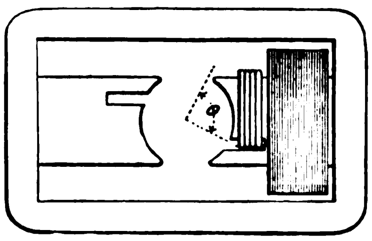


FIG. 1.—COMPOSITE FIELD WINDING.

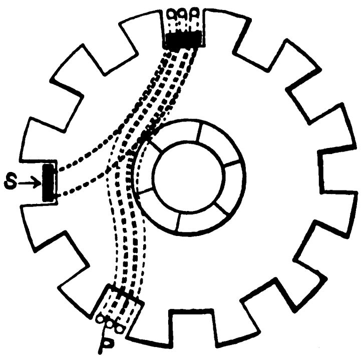


FIG. 2.—ARMATURE WINDING.

stant. The result is that a larger proportion of the lines is usefully cut by the secondary winding, until at full load practically the whole of the flux is available for producing the e.m.f. in the secondary winding, so that the transformation ratio of secondary and primary e.m.f. is greater at full load than at light loads.

Pollak-Virag Writing Telegraph.—In our English contemporaries, as well as in the "Elektrotechnische Zeitschrift," descriptions are given of an apparently important improvement in the telegraph system devised by Messrs. Pollak and Virag. The most improved form of the receiving apparatus in its former form is shown in Fig. 3. The device, T, shown at the right hand, is the principal feature; it is a telephone whose diaphragm is moved by impulses received from the line; to the diaphragm a stem is attached which moves one of three points on which a small concave mirror rests; the mirror is "held in position on two pointed prongs of one pole of a stationary permanent magnet, and one movable prong constituting the other pole of the magnet by having cemented on its back a small piece of soft iron;" to this movable prong the stem from the telephone diaphragm is attached. A beam of light falls upon the mirror, which and when reflected registers the movements of the diaphragm on sensitized paper. The record is obtained as a zig-zag line running from left to right, in the following way: the source of light is a stationary incandescent filament surrounded by the cylindrical metal mantle, L, in which a helical slit of one turn is cut, so that when the mantle is revolved the beam of light falling upon the mirror is moved from right to left and the reflected beam is moved from left to right. The principal new improvement is that ordinary handwriting is produced in place of a simple zig-zag line. For this purpose the device, T, is changed into a double device shown in Fig. 4; there are two telephones and the small concave mirror reposes upon one fixed point and two movable points. One telephone moves the mirror about a horizontal axis, the other about a vertical axis, so that acting simultaneously the telephones can cause the reflected spot of light to trace any desired curve. The characters to be transmitted are analyzed at the sending end into its horizontal and vertical components and compounded at the receiving end by the two telephones. A diagram of the circuits is shown by Fig. 5, in which B is the transmitter drum between which and the brush fingers a perforated strip passes. Two line wires, L L, are necessary.

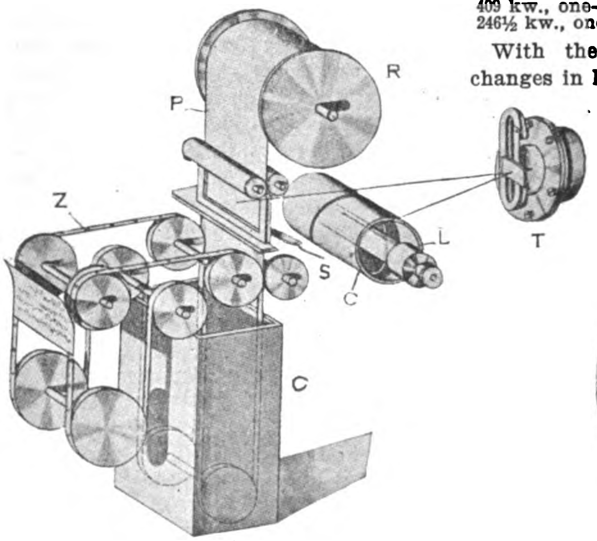


FIG. 3.—ARRANGEMENT OF POLLAK-VIRAG APPARATUS.

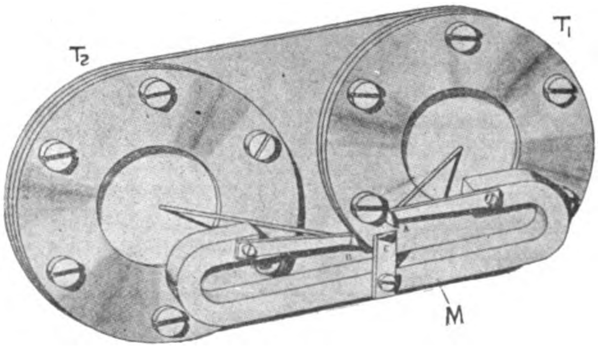


FIG. 4.—THE TWIN TELEPHONES.

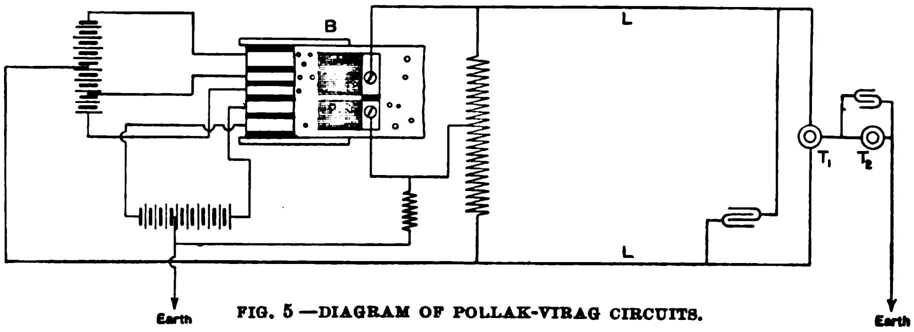


FIG. 5—DIAGRAM OF POLLAK-VIRAG CIRCUITS.

New Parsons Steam Turbine.—In a recent issue of the London "Electrical Review" there appears an interesting description of a new Parsons steam turbine for the central station of Elberfeld, Germany. It is to drive a three-phase alternator at 4000 volts and 50 cycles when running at 1500 r.p.m.; the output is 1000 kilowatts with a power factor of 0.80. Some notes are given on a complete test of the steam turbine made at the Parsons works by Messrs. Lindley, Schroeter and Weber, before the set was accepted. At an average steam pressure of 162 lbs. per square inch and 14.3 degrees of superheat the following results were obtained:

Output.	Steam per kw.-hour.
1190 kw., overload	19.8 lbs.
995 kw., full load	20.1 lbs.
745 kw., three-quarter load	22.2 lbs.
409 kw., one-half load	25.4 lbs.
246½ kw., one-quarter load	33.8 lbs.

With the electrical governor sudden changes in load of from 12 to 62 per cent. gave an average variation in e.m.f. of 1.1 per cent. The drop of voltage on increasing the load from zero to full non-inductive load, the speed and excitation remaining constant, was only 1.02 per cent. After a six-hour run the rise of temperature was not to exceed 40 deg. C.; only the core exceeded this figure, and by ventilation it will be brought down to less than 40 deg.

Determining the Frequency of an Alternating Current.—In the course of some physiological equipments, A. Samojloff has found a simple method of measuring the frequency of an alternating current, which is described in a recent number of Drude's "Annalen des Physik." The alternating current, the frequency of which is to be measured, is supplied to an incandescent lamp which illuminates a disc consisting of white and black sectors. This disc is revolved and the speed of revolution is varied, until the disc appears to stand still; then the number of alternations of the current is equal to the product of the number of white sectors and the number of revolutions of the disc; the number of cycles is one-half of this. Care must, of course, be taken not to revolve it at two or three times the proper speed, or any other multiple, at which the disc will also appear to stand still.

Electric Heating Apparatus.—A recent issue of the London "Electrical Engineer" contains a description of electric heaters made by the Prometheus Company, of Bockenheim, Germany. The electrical energy is converted into heat by means of resistances formed of thin films of precious metals, such as gold, platinum, etc., deposited on an insulating base of mica, enamel, or other suitable material; it is said that resistances up to 25,000 ohms can easily be obtained. The stoves for these strips are circular, as shown in Fig. 6. The strips are mounted in two rows on a frame fitting into a circular case; the outer row radiates heat directly and a continuous current of air passes up and is heated between the two rows. In order that the radiators may act as quickly as possible, the amount of heat-absorb-

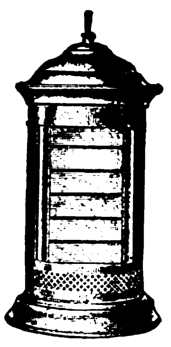


FIG. 6.—HEATER.

ing material is reduced to a minimum. For a resistance of 120 ohms a mica strip 6 ins. long, 1.2 in. wide and 0.0004 in. thick, is used, coated with a film of the precious metal; the combination absorbs but little heat and practically the whole of the energy is at once available for radiation. To ensure durability it is desirable that the temperature of the strips should not exceed 450° C., which corresponds to 70 or 75 watts per strip. At 90 or 100 watts the strips show dull red in the dark and oxidation would then occur.

Solignac Compensator.—In a recent issue of "L'Eclairage Electrique" J. Reyval describes an interesting device for the starting and speed regulation of a traction motor; this device is called the Solignac compensator and its principle is illustrated below. The main purpose is to waste no energy in external resistances. In the engraving B represents the car or vehicle motor, which is series wound. The feature of the arrangement is the employment of two dynamos, A and C, rigidly coupled together, like an ordinary motor-generator; A is series wound and connected in series with the motor, while the exciting coil of C is connected across the line; the armature of C is in parallel with the motor, as shown in the figure. How this device acts may best be seen from the controller, diagrammatically shown in Fig. 8. The cross-hatched surfaces are metallic contact surfaces and the controller moves the irregularly-shaped plate shown at the right of the diagram from right to left, so that different connections between the circuits of A, B, C, are made. The two plates, marked + and —, are permanently connected to the source. On the first notch of the controller, represented by the line 1, the motors, A and B, are connected to the source but C is not; A, therefore, runs up to speed quickly, as it is not loaded, while the main motor, B, drives the car which starts up slowly; the two being connected in series, the counter e.m.f. of A, which gets up to speed quickly, prevents an excessive rush of current through B. On the second notch of the controller, represented by line 2, the connections of A and B are left as before, while the field of C is now connected to the supply circuit, its armature being connected in parallel with B as shown in Fig. 7. The machine, C, now acts as a dynamo, being driven by the motor, A, and the current induced in its armature is supplied to the motor, B, thus adding to that coming directly from the source. At the fourth notch, represented by the line 4, A and C are disconnected and the motor, B, alone is connected to the source. On notch 3 the connections are same as 2, but in passing from 3 to 4 resistances are gradually inserted in the field circuit of C, weakening it and diminishing the load on the motor, A, which, therefore, increases in speed and in turn diminishes the voltage available at the terminals of B, which decreases its speed; this last change is used for decreasing the speed of the car.

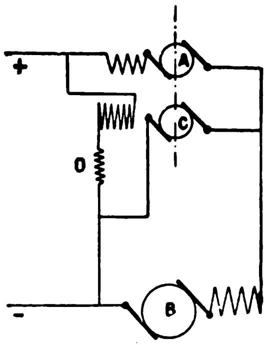
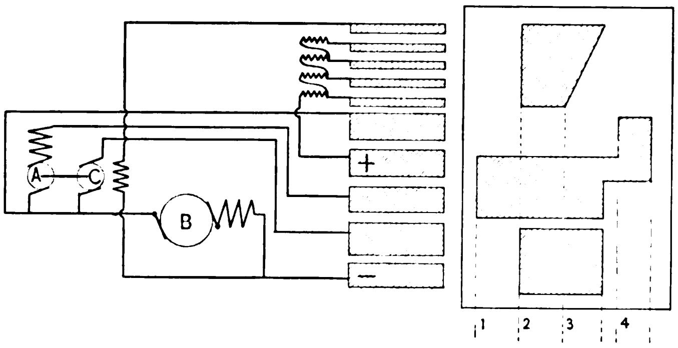


FIG. 7.—CIRCUITS.



8.—CONTROLLER CONNECTIONS.

The Direct-Current Arc.—Recent issues of our French and British contemporaries give accounts of a paper read by Mrs. Ayrton before the International Electrical Congress. In Fig. 9 a characteristic curve is given for the relation between the arc length and the total light emitted from a 10-ampere arc; it shows a curious dip at the point, *x*, the physical meaning of which appears from what follows. With large currents and small arc lengths, the negative carbon assumes a much more tapered form than when the currents are small and the arc length large; and in the former case a very sharp supplementary points grows at the extremity of the negative carbon, which disappears entirely when the arc is lengthened. At a certain point the exposure of the crater is actually reduced by increasing the length of the arc, since the loss due to the change of the form of the negative carbon more than compensates for the gain due to the increased gap. The commercial significance of the observation is not in the absolute gain of light by the better exposure of the crater, but in the smaller power required to burn short arcs, so that if equal amounts of light can be obtained from long and short arcs, it is more economical to burn short arcs than long ones. The investigation of the authoress points to progress in two directions: First, the use with given carbons of the shortest arcs and the largest currents possible, without approaching too near to the hissing point; secondly, the production of a negative carbon which, when burning in the arc, shall have an extremity even longer and thinner than the carbons used at present and which, nevertheless, shall burn much more slowly.

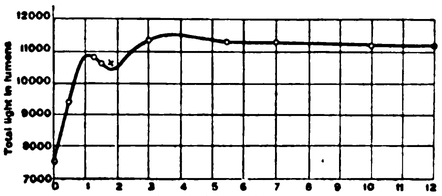


FIG. 9.—CHARACTERISTIC CURVE.

Electric Automobiles.—A recent issue of the "Elektrotechnische Zeitschrift" contains an editorial abstract of the official report made by Dr. Kallmann on the competitive tests of electric automobiles held in Berlin last April. An ideal automobile could have gotten 50 points; the three best automobiles got 41.7, 39.7 and 38.5 points, which indicates that automobilism is no longer "in its infancy." The weight of the battery varied between 121 lbs. and 286 lbs. per kilowatt-hour, while the average values for all 13 automobiles was 165 lbs. The prices of the battery for passenger automobiles varied between $250 and $500, while those of the automobiles themselves, including the batteries, varied between $925 and $2250. The opinion is expressed that in future the price of the battery for a passenger automobile, running over 19 miles on one charge, may be about $260. One of the exhibiting manufacturers guarantees to keep the batteries in good order for three years and to replace them, if necessary, at 30 per cent of the first cost per year. Regarding the consumption of energy per ton-mile, the best result was 91 watt-hours for an average speed, while at the highest speed, the consumption on the same automobile was 135 watt-hours per ton-mile. For most automobiles the energy consumption does not vary greatly with the speed; it is, therefore, recommended for the sake of economy to run at the highest allowable speed that is possible.

Boucherot Compound Alternator.—In this department of the September issue a description of the Hutin and Leblanc compound alternator was given. In a recent issue of the "Elektrotechnishe Zeitschrift" was printed an article on a compound alternator designed by Boucherot and also shown at the Paris Exposition. Boucherot obtains the same results as Hutin and Leblanc, but his means differ greatly in some points from those of the latter. Both use a special exciter which is itself excited by alternating current and gives out direct current. To get a direct current with a rotary field without the use of revolving brushes, Boucherot uses a direct-current dynamo armature provided with an ordinary collector, but the winding of the armature is of a special form; the armature has two or three windings instead of one, and the number

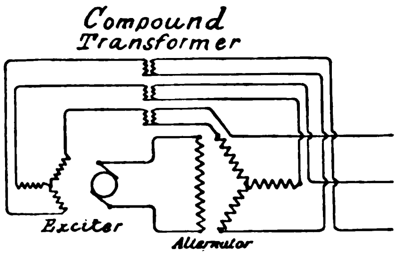


FIG. 10.—TRANSFORMER CONNECTIONS.

of turns in each winding between two poles varies according to a sinusoidal law. In order that the voltage at the terminals of the alternator shall always have a constant value, independent of the load and the power factor, it is necessary and sufficient that the direct current furnished by the exciter shall vary according to a certain law which requires that the current be a certain function of the load and power factor. This may be done by exciting the field of the exciter by the combined effect of a shunt and series three-phase current from the main generator. Hutin and Leblanc use for that purpose two rotary fields in their exciter, one in series, the other in shunt with the main generator. Boucherot has only one rotary field in his exciter, but he interposes between the alternator and exciter a "compound transformer," as shown in Fig. 10. It will be seen that the three-phase currents in the exciter field depend on both the voltage and the main current of the generator, therefore compounding the latter similarly to the action of the shunt and series coils in a direct-current compound machine.

Some Recent Electrical Patents

Step-by-Step Mechanisms.—In step-by-step motors, such as those used in automatically-wound clocks, some difficulty is found in obtaining the maximum travel of the armature which actuates the ratchet wheel. When a single make-and-break contact is employed, unless the mechanism is rather complicated, the armature tends to flutter midway of its extremes of travel, never reaching either one. Besides the disadvantage of uncertain operation, this action involves rapid deterioration of the contact points. The arrangement shown by Figs. 1 and 2 has been invented by David Perret with a view to eliminating these troubles. Fig. 1 shows the mechanism with the armature released and the circuit closed through the magnet; Fig. 2 shows the condition immediately following, when the magnet has attracted its armature. In this position the contact arm, I, has removed its contact, N, from the end of the screw, O, by a rapid snapping action caused by the pawl, V, falling into the notch on the ratchet wheel. The arm, L, remains in contact with the screw, O, up to the last moment before the pawl falls into the ratchet notch. The next operation is obviously the return of the armature lever to the position shown in Fig. 1. This movement carries the ratchet wheel around one notch, but before the contact arm, L, has closed the circuit at N, the pawl, X, lifts the arm, F, breaking the circuit at I and it remains broken there until the armature lever reaches the extreme limit of its travel, when the pawl, X, snaps into the notch in the ratchet wheel and closes the circuit at I. It will be obvious from a consideration of the mechanism that the armature lever invariably accomplishes its full travel without any fluttering in an intermediate position, as the circuit is not opened at N until the armature has reached its limit of travel toward the magnet core and the circuit is not restored at I until after the spring has forced the armature lever to the other extreme of its travel. Patent No. 658,997.

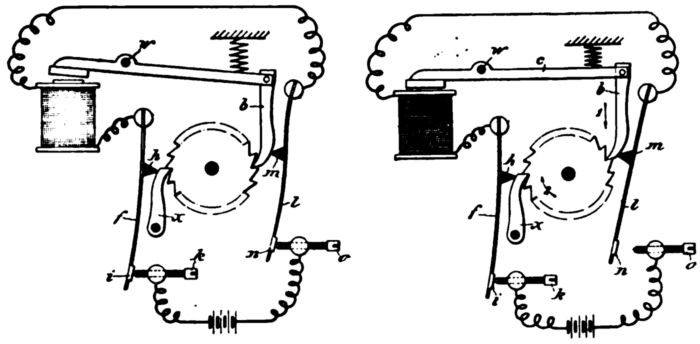


FIG. 1.—STEP-BY-STEP MECHANISM.—FIG. 2.

Globe Holder for Enclosed Arc Lamps.—It is customary in large stations where enclosed arc lamps are used to clear the envelopes, or inner globes, systematically at the station and also to insert fresh carbons in the lower holders at the same time, so as to simplify the work done by the trimmer on his circuit. When the globes are cleaned and the lower holders are re-carboned the carbon holders and globes are placed in a rack in readiness for the trimmer. With a view to providing a simple device which will securely hold the inner globe or envelope, and facilitate the transportation of the carbon holder, carbon, and globe, Henry C. Spinney has devised the arrangement shown by Fig. 3. The inner globe, or envelope, is secured to a plate, I, which is threaded on the stem of a tube, J. The upper end of this tube is spread, as shown more clearly in the lower part of the engraving, so as to engage with the sloping wall of the globe, and prevent vertical motion on its part. It is obvious that securing the plate, I, up on the stem of the tube, J, binds the globe securely to the upper surface of the plate, which is faced with a packing ring, L, of suitable material in order to make an air-tight joint. The flared tube, J, is then secured into the carbon holder, D, which is of the ordinary tubular type provided with a set screw, G, for planting the carbon. It is obvious that the trimmer can be provided either with the enclosing globe and its holder alone or with the complete carbon holder, carbon and globe assembled ready for insertion in the bottom frame of the lamp. The globe holder is held in the socket of the frame yoke by means of a set screw, H, indicated by dotted lines in the upper engraving. The carbon may be inserted in this holder either at the top through the bottom, the plug, F, in the bottom of the carbon holder being removable. Patent No. 659,706.

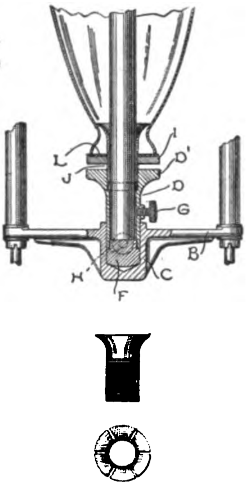


FIG. 3.—GLOBE HOLDER.

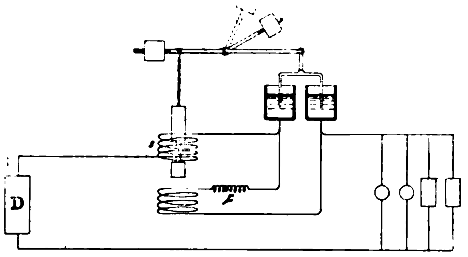


FIG. 4.—CIRCUIT-BREAKER.

Self-Restoring Circuit Breaker.—A rather ingenious method, although impractical from an American standpoint, has been patented by Arthur Bromley Holmes, of Liverpool, for automatically restoring a circuit-breaker which has been thrown by an overload as soon as the overload shall have been removed from the circuit. In Fig. 4, *D*, is the dynamo and *S* is the ordinary circuit-breaker solenoid. The apparatus is provided with a mercury break instead of the ordinary knife-switch arrangement, and the solenoid has an auxiliary coil below the main coil, in series with an adjustable resistance, *r*; this circuit being connected in shunt to the break. It is obvious that when an abnormal load through *S* pulls the plunger of the solenoid down and opens the circuit, the supplementary plunger will come within the influence of the supplementary coil, which is energized by the opening of the mercury break and the circuit-breaker is thus held open. The resistance, *r*, is so adjusted that the auxiliary coil of the circuit-breaker will not hold the plunger down under the influence of a normal current; consequently, as soon as the abnormal flow ceases, the right-hand weight, which is the heavier of the two, restores the circuit-breaker to its normal closed-circuit position. Patent No. 656,324.

Composite Dynamo Brush.—The expedient of making up dynamo brushes of alternate layers of different metals for the purpose of suppressing sparking is not new, several types of this class of brush having been devised during the past ten years. The most recent form is one patented by C. Endruweit, and consists of metallic and carbonaceous leaves in alternate layers. The metallic low resistance leaves are of chemically-pure metal foil and the high resistance leaves are obtained by carbonizing some organic substance, such as paper, which is previously treated with a liquid that favors its cohesion with the metal foil. The object of this construction is to provide a brush which will be flexible and at the same time have a structure divided into alternate high and low-resistance sections. Patent No. 658,431.

Third Rail for Electric Railways.—Fig. 5, which is almost self-explanatory, illustrates the fundamental features of a protective system for the conductor rail of a third-rail electric railway system, which has been patented by B. C. Seaton. The conductor rail, 22, is protected on one side by the curved shield, 25, of insulating material, which is supported as indicated in the diagram, and protected on the opposite side and over the top by the arched shield 29, 30 and 31. These shields are composite in structure; 25 is insulating material and is protected by an outer sheathing of metal; similarly, 30 is insulating material and is protected on the outside by the sheathing, 31, and on the inside by the sheathing, 29. The contact shoe is pivoted to the end of a horizontal arm, as plainly shown in the sketch. The arrangement obviously precludes all accidental contact with the conductor rail, the only access being horizontally through the opening between the edges of the two shields. Patent No. 660,738.

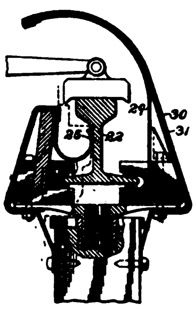


FIG. 5.

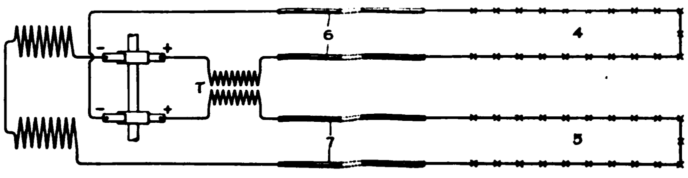


FIG. 6.—CABLE PROTECTING ARRANGEMENT.

Cable Protection for Circuits Carrying Fluctuating Currents.—To protect underground cables from puncture due to the electrostatic capacity of the cable when the conductor carries a fluctuating current, such as that from a open-coil arc-light dynamo, Charles M. Green and John G. Callan have devised and patented the arrangement shown diagrammatically by Fig. 6. The diagram shows two work circuits, 4 and 5, supplied from a multi-circuit brush dynamo, and including sections of cable, 6 and 7. In order to neutralize the capacity effect of the cables an inductance is connected in series with each circuit, the two inductances being arranged in inductive relation to each other. The inductance consists simply of two coils wound on a core like the coils of a transformer except that the two coils contain the same number of turns. This arrangement is provided in order to avoid the drop in potential which would necessarily result if an inductance were put in one circuit independently of the other one. The mutual inductance of the two coils wipes out their counter e.m.f. Patent No. 659,664.

NEW BOOKS.

The Gas Engine Handbook. By E. W. Roberts. (Second Edition.) Cincinnati, Ohio: The Gas Engine Publishing Company. Flexible leather; 240 pages, 3½x5½ inches; 40 illustrations. Price, $1.

This edition of Mr. Robert's little handbook contains considerable new matter in addition to that in the first edition, and the text has been pruned of nearly all typographical errors. An appendix on two-cycle engines has been added, and the original matter has been revised and elaborated. The book will be found of much value by anyone at all concerned with either the construction or the operation of gas and oil engines.

Modern Electric Railway Motors. By George T. Hanchett. New York: Street Railway Publishing Company. Cloth; 200 pages, 6 x 8¾ ins.; 157 illustrations. Price, $2.

This is a praiseworthy combination of didactic and descriptive work which occupies a hitherto vacant niche in American electrical literature. The book contains a plain, non-mathematical presentation of the fundamental principles of design and a valuable exposition of modern practice in railway motor construction. The author evinces a strenuous partiality for worm gearing, which is scarcely compatible with the soundness of his suggestions in other directions, but this is about the only feature of the entire book that provokes actually adverse criticism. The book is very clearly written and profusely illustrated.

Alternating-Current Phenomena. By Charles Proteus Steinmetz, assisted by Ernest J. Berg. Third edition. New York: Electrical World and Engineer. Cloth; 525 pages, 6 x 9 ins.; 210 illustrations. Price, $4.

This edition of Mr. Steinmetz's work contains a great deal of matter not given in previous editions, and really attains almost to the rank of a classic. All commercial forms of alternating-current phenomena are treated in three ways—graphically, symbolically and topographically (so-called)—and diagrams are plentiful for the illustration of the three treatments. The book is mathematical in character, however, and will not be of assistance to anyone devoid of a thorough knowledge of what might be termed intermediate mathematics. To students who have mastered plane trigonometry and geometry and vector analysis it will be invaluable.

Dynamo Electric Machinery. By Samuel Sheldon, A.M., Ph.D. New York: D. Van Nostrand Company. Buckram; 282 pages, 5x8 inches; 202 illustrations. Price, $2.50.

This book is avowedly intended primarily as a text-book for use in connection with the teaching of electrical engineering in educational institutions, and is admirably adapted for that purpose. It it also an excellent reference book for those interested in dynamo design or construction, but it is not sufficiently elaborate as to explanatory matter for the purposes of self-instruction. The section on armature windings, for example, is limited to bare statements of fact as to terminology and the kinds of windings that are practicable; and the diagrams are mostly too small to be useful, besides being not well chosen for the illustration of current practice. The curves relating to the magnetic properties of iron and steel are particularly good, but the corresponding table is not nearly full enough to be of practical value. The book is clearly written, accurate throughout, except for a few typographical errors, and lacks only amplification to make it as highly useful practically as it now is academically.

A Treatise on Electric Law. By Joseph A. Joyce and Howard C. Joyce. New York: Banks Law Publishing Company. 1133 pages. Price, $6.50.

This book is intended especially for officers, heads of departments and the counsel of corporations which use electricity in any of its forms. It treats of almost every subject (save patent law) which arises in the various legal complications and emergencies in which the electric companies become involved. The incorporation, the license, the taxation, the duties and the privileges of such corporations in all their manifold relations to the public are discussed. The work surpasses its predecessors in the same field in size and comprehensiveness, and in many of its chapters in the careful examination and condensation of the law in each of the several States; especially as relates to those questions which are novel and upon which the courts in various jurisdictions have differed. Here, within the covers of a single volume, are found discussions of questions which ordinarily could only be answered by referring to a dozen different text-books upon as many different subjects. The work seeks at once to be a digest of cases and a treatise upon fundamental principles. A work upon these lines is always open to criticism, and no two persons would wholly agree as to what subjects should be included or omitted; but the authors of this work seem to have practical rather than theoretical ends in view, and appear to have very well attained their objects.

NOTES.

Albany-Hudson Electric Railway.—The third rail electric railway between Albany and Hudson, which has been under construction for some time past, was officially opened on November 22. The initial train left Hudson at 11:40 a. m. and arrived at Rensselaer, 37 miles distant, exactly one hour later.

Electrical Wiremen's Association. — The first anniversary banquet of the Inside Electrical Wiremen's Association was held on November 15, in Commercial Hall, Boston, and was a marked success. President Jas. L. Winn was toastmaster, and Past Presidents J. S. Cartwright and A. M. Campbell, and Homer Corse delivered felicitous speeches which were highly appreciated by the members present.

Russian Telephone Franchises Sold.—The franchise for telephone exchange operation in Russia were sold at auction on November 20. The award of franchise was determined by the rental rates offered by the various bidders. The rate of the successful bidder in Moscow was 75 rubles ($31.50), and that in St. Petersburg was 45 rubles ($19) per annum. The government retained the ownership and control of the long-distance telephone lines.

Electrical Transmission Over 153 Miles. —The Snoqualmie Falls Power Company, of Seattle, Wash., recently performed the notable feat of driving a motor 153 miles distant from the power house. All of the transmission lines of the company were connected up in series so as to obtain a maximum length of circuit. The test was made only for experimental purposes to demonstrate the practicability of power transmission over such long distances.

Underwriters' National Electrical Association.—The annual meeting of the electrical committee of the Underwriters' National Electrical Association will be held at 32 Nassau street, New York city, on Tuesday, December 11, at 10 a. m. At this meeting a special committee will present its report on the grounding of low-potential circuits and such changes in the rules as may be necessary to allow this. Any one who is interested in the improvement of the National Code is invited to be present.

The Close of the Paris Exposition. — —At midnight of Monday, November 12, which was the last day of the Paris Exposition, the lights were cut off and the formal termination of the exposition was announced by firing a cannon on the first story of the Eiffel Tower. During this final day the attendance was kept down by a cold, drizzling rain; the price of tickets dropped off until five tickets could be bought for one cent, and later on during the day tickets were given away in order to induce attendance. The official statistics show that about 50,000,000 persons passed through the gates as compared with 25,122,000 in 1889. The largest attendance on any one day was 600,000.

Electrically-Driven Sewer Pumps. — The Sydney (New South Wales) authorities have introduced electrically driven pumps for removing sewage. Twenty-one motor-driven pumps raise the sewage to a high level, whence it runs far out into the ocean at Bondi. Power for the pumps is supplied from the 500-volt government railway system at Ultimo.

Electrical Progress in North Carolina.—A company has just been formed under the name of the Wil-Kin Electric Company at North Wilkesboro, N. C., with a branch office in Elkin, 20 miles distant. The immediate purpose of the company is to establish a telephone line between North Wilkesboro and Elkin, to which end it has bought out the Wilkesboro Telephone Company and the Elkin Telephone Exchange, and is rebuilding the latter exchange.

Municipal Lighting at Collinwood, Ohio. —The municipal electric lighting system recently installed at Collinwood, Ohio, by the Chase Construction Company, of Detroit, was started up about the first of November, after a trial test of four days, and the town is highly elated over the success of the inauguration. The station plant comprises an 80-light Fort Wayne arc dynamo and a 1,500-light Fort Wayne alternator, driven by a 150-h. p. Russell-Corliss engine. The arc lamps are Adams-Bagnall enclosed arcs.

Progress in Wireless Telegraphy.—It is stated in a recent dispatch from London that telegrams were successfully sent by the Marconi system between the Belgium steamer, Princess Clementine, and the town of La Panne, nearly fifty miles distant across the sea. A wire hook at the end of the topmast was employed on board the steamer. The ship was nearing Dover at the time and frequent messages were sent at the rate of twenty words a minute until the landing at Dover, which is sixty-one miles from La Panne, was made. Later on, a message was sent from the Princess Clementine to Mr. Marconi's wireless station at Dovercourt, Essex, a distance of between eighty and ninety miles.

Interurban Railway Opened in Canada.—The Von Echa Company, made up of Pennsylvania business men, is constructing an electric railway from Woodstock to Ingersoll, Ontario, and on Nov. 8 the section of the road between Woodstock and Beechville, a small town about midway on the line, was opened to the public. It was a gala day for Woodstock, and the people turned out *en masse.* The newspapers put on "scare heads" filled with electric thrills, and the editorial columns tried to make amends for some less complimentary utterances of a few months ago, when it was the consensus of Oxford County opinion that the road was to be some kind of "Yankee bluff." The road will probably be extended beyond Ingersoll to Embro later on.

Engine Builders' Association..—On Tuesday, December 4, 1900, the association formed by the high-speed engine builders of the country will hold its annual meeting in New York City at Sherry's, Fifth Avenue and Forty-fourth Street. The afternoon session promises to be unusually interesting, as papers will be read on "The Relation Between the Engine and Generator" by representatives of the General Electric and Westinghouse Companies, from the standpoints of lighting and power. Mr. Armstrong, who has given much attention to steam-engine tests, will read a paper on "The Economy of the High-Speed Engine." At this session builders of high-speed engines, whether members of the association or not, will be welcome. A dinner will be given the members at Sherry's at seven oclock.

Constant Potential Generators in Series.—The Chicago Electric Traction Company, which for several years has operated a storage battery road in the southern part of Chicago, is making the change from storage battery to trolley. The storage battery equipment on this road has given good service, but the difficulties of working it on branch lines where the cars could not regularly run past the power house to change batteries made it advisable to change to the trolley. In connection with this change a rather unusual expedient was resorted to by the consulting engineer, Mr. B. J. Arnold. There was considerable unavoidable delay about getting the 500-volt railway generators. The generators used for charging the storage batteries were 220-volt machines. To operate part of the road by trolley, two of these generators were connected up in series. No trouble was experienced.

Electrical Equipment of the New York Elevated Road.-The first official trial of an electrically-equipped train on the Manhattan Elevated Railway was held on November 22, on the tracks of the Second avenue line between Sixty-fifth and Ninety-third Streets. The test train made five trips between these two stations, and attained a speed of about 35 miles an hour. A private trial was made on the night of November 19, on which occasion a speed of 40 miles an hour was attained. When the lines are finally equipped it is thought that the running time on the Sixth Avenue line between the Battery and 155th Street will be reduced from 50 minutes, the present schedule, to about 40 minutes or a trifle less, and express trains will make the run in about 25 minutes. Although the present schedule is 50 minutes, this is seldom attained during the morning and evening rush hours, the actual time being nearer 70 minutes. The greater acceleration ability of the electric trains, however, will undoubtedly reduce the running time very materially.

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Third Rail vs. Overhead Trolley.

It is quite probable that future developments will show that the opening of the Albany-Hudson railway, noted in another column, constitutes what might be termed a mile-post in the progress of electric traction. It is the first departure from the use of the cheap and time-honored trolley on interurban surface roads, and a most sensible departure. The experience at Baltimore with a heavy, costly and unsightly overhead structure has demonstrated that this method is totally inadequate for anything approaching heavy traction, and the overhead arrangement is now being displaced by a third-rail installation. Even for much lighter service than that in the Baltimore & Ohio tunnel, the overhead trolley is but a poor medium of transmission. On the short seashore lines running out of Brooklyn the progress at night of elevated railway trains along surface tracks may be followed easily from afar by reason of the ghastly pyrotechnical display at the trolley wheels. Two trolleys are used on each train, but twenty of them would not give extravagant contact surface between the wire and the wheels.

The third rail possesses many advantages for surface roads in outlying districts, as well as for elevated railway service, in which it originated. There is always a firm, ample contact available; the irritating delays incident to "losing the trolley wire" are eliminated; there is practically no limit to the volume of current that may be economically transmitted to a train, and the conductor rail can be effectually insulated and protected mechanically. Once it is in place, the rail is not given to the vagaries of an overhead trolley wire; a contact shoe may hang and be rendered unfit for further duty (although this is a remote contingency), but no one ever knew a conductor rail to fly up and disport itself in the unseemly manner which characterizes the evolutions of a broken trolley wire.

All of these facts are well known to railway engineers, along with many other incidental advantages accruing from the use of the third-rail system, as compared with the overhead trolley. The use of the system for surface work inaugurated by the Albany-Hudson road indicates not that the engineering fraternity has experienced a belated awakening, but that some engineers have succeeded in hammering into the heads of some capitalists a glimmer of technical reason. It seems little short of ridiculous that hard-headed men of dollars should require the amount of argument and financial loss that they do in order to consider technical matters—especially electrical engineering—in a rational manner. One would think that the simple inspection of some inadequate installation would develop wisdom, but as a rule it does not.

◆

Double-Current Generators.

Of course one flies in the face of Providence and invites classification with fossils, heretics or lunatics, in offering adverse comment upon any "development" of the art. Notwithstanding all this, we confess to a hopeless inability to discover a *raison d'etre* for the double-current generator, from an engineering standpoint. We do not recall an instance where greater simplicity or flexibility has been secured by its use. In the Montmorency Falls water-power plant, which forms the subject of our leading article this month and is a fine example of engineering skill, a machine of this type is used, but no excuse is offered. If the supply of direct current to the near-by section of the railway justified a mixture of generator types, a standard railway generator would have fulfilled all requirements in that direction. No reason appears on the surface why the alternating-current feeder supplied by the double-current generator could not have been just as efficiently served by one of the regular alternators, and such an arrangement would have eliminated the special 2.75 to 1 transformers.

The solitary advantage obtainable by the use of double-current generators is the ability to supply both classes of current and still have but one type of station machinery. On the debit side, however, are two serious and one incidental disadvantages, to-wit: the compulsory use of station transformers capable of passing the entire alternating-current load; interference with the regulation of one system by sudden fluctuations in the load on the other side, and the enforced use of a low frequency. The low frequency may or may not be of importance, according to conditions of operation. For stations of such size as to permit the use of very large units, facilitating the use of many magnet poles, double-current generators might be tolerable, provided the character of the two loads were such as to justify the expense, but even in this case it is highly questionable that any actual operating advantage would be conferred by double-current machines as compared with honest alternators and direct-current generators.

Real simplicity and flexibility as to generator equipment is attainable only by supplying a single class of current for all classes of service. When conditions, such as a combination of widely distributed incandescent service and electric railway supply, demand the generation of both direct and alternating currents, there is not apparent any gain to be had from mixing them up at the source, whereas there is the expensive objection of step-up transformers and auxiliary regulating apparatus, the latter being necessitated by the crippled regulation on the alternating-current side. Even the use of auxiliary regulators will not always insure satisfactory results. Where there is no electric railway service to be supplied it is, of course, practicable to eliminate the direct current entirely, and the use of double-current generators would not have even the semblance of an excuse.

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Steam Engine Governors.

The control of engine speed by means of an extraneous governor or regulator, somewhat after the manner of water-wheel control, has been suggested at intervals during the past fifteen years (and possibly earlier), but the suggestion has never borne fruit because it has always been regarded as impractical and retrogressive. As a general proposition, an independent engine governor would be an unnecessary complication; for some cases, such as an engine direct-coupled to an electric generator, the idea is not so foolish as it may at first appear. Nothing is more sensitive than an electrical relay, and no reason is apparent why an engine-generator set should not be more effectively controlled by a combination of such a relay with a mechanism operating a variable cut-off valve on the engine than by the modern wheel governor, shunt field rheostat and series field winding.

An electrically-controlled engine regulator could be made to vary the speed of the generating set to suit the load, rendering compounding unnecessary; it would also inherently be a safety device and act to cut off steam at such a point as to allow the engine to run only at minimum operating speed when the dynamo delivered no current. Such a governor might be too sluggish for railway service, where the speed might be required to change 10 or 15 per cent within a few seconds, but this is a point which can only be conclusively determined by experiment. The feasibility of the plan for generating sets dealing with better-behaved loads is beyond doubt. Its application would provide a simple means for dividing the load accurately between two or more generators in parallel, and permit working the generators at their maximum magnetic efficiency at all loads, eliminating the necessity for over-saturation at full loads.

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Compound-Wound Dynamos.

A compound-wound dynamo performs most admirably all of its intended functions as long as it operates alone or in parallel with other machines of identical magnetic characteristics, but no one has ever succeeded in making two or more dissimilar machines divide the load properly when running in parallel. Fortunately, the discrepancy is not usually so serious as to render parallel operation dangerous, and in many cases it is not obtrusively noticeable. The impossibility of adjusting dissimilar machines, so that they will divide the load proportionately, is due to the fact that the series or compounding windings of all the dynamos are in multiple when the machines operate in multiple, and the adjustment of any series field shunt affects not only the field winding to which it is attached but all others that may be in circuit. Individual adjustment of the compounding of a dynamo, therefore, is entirely vitiated when the machine is coupled in parallel with others on a common circuit.

One obvious remedy for this is to provide a variable resistance in series with each series winding instead of in shunt relation to it; then any required division of the main current between the several series windings could be obtained. Such an arrangement, however, would involve the converse disadvantage that a machine thus equipped could not be adjusted for different degrees of compounding when operated alone. This leads to a combination of the two methods of adjustment, namely, a variable resistance in shunt to and one in series with the series field coils. A single resistance strip (or series of strips, perhaps) connected between the equalizer junction and the dynamo terminal can be made to fulfill this requirement by permanently connecting one terminal of the series field coil to the equalizer junction and adapting the other terminal to be adjusted along the length of the resistance strip. As the connection for this latter terminal would be moved along the resistance strip toward the dynamo terminal the compounding would be increased, and *vice versa*.

The operating objection to this method lies in permanently having the whole resistance strip in circuit; the mechanical objection is that a considerable portion of this strip must be of sufficient cross-section to carry safely the full current of the dynamo. The difficulty of providing a resistance strip of rational length to carry several hundred or several thousand amperes and yet serve as a comparatively high-resistance shunt to the series winding will be apparent upon short reflection. The method is admirable for machines of moderate size, however, and actual experience with it in connection with such machines has demonstrated that it is wholly practical. It might be adapted to large lighting and railway generators by dividing the resistance strip into sections somewhat like a rheostat, and mounting it in an individual frame on top of or very near to the generator. This would be rather clumsy, besides compelling the use of heavy conductor bars of very low resistance between the generator and the series rheostat, as it might appropriately be termed.

For generators of great output, say 1,000 kilowatts and over, it is a question whether better results all around would not be obtained by the use of a plain shunt field winding, compensating for internal and external ohmic drop by means of individual series-wound booster dynamos, either independently driven or coupled to the generator shafts. If there were more circuit feeders than generators, a booster would be inserted between each generator and the switchboard, but if the number of generators were greater than the number of feeders, it would be less expensive to provide a booster for each feeder. Or, again, a single booster could be made to serve the whole plant by inserting it in a trunk connection between the generator bus-bars and the feeder bus-bars; this, however, would be very inflexible, although it would, of course, simplify the station equipment. Any of the booster arrangements suggested would evidently permit absolutely proportionate division of the load between the several generators at all points of the load curve, unless the differences in armature resistances were absurdly great.

DESIGN FOR A 2-H.P. SINGLE-PHASE INDUCTION MOTOR.

BY J. C. BROCKSMITH, M. E.

The motor here described is of the same general design as the two which were described in the October and November issues of this paper. The machine is of 2 horse-power rated capacity, with a temporary overload capacity of about 50 per cent, and will run at about 1800 r.p.m. on a 60-cycle circuit, and about 1875 r.p.m. on a 125-cycle circuit. The stator winding may be connected up so as to give any multiple of four poles, but only two methods of connection are shown, as these are sufficient for all ordinary cases.

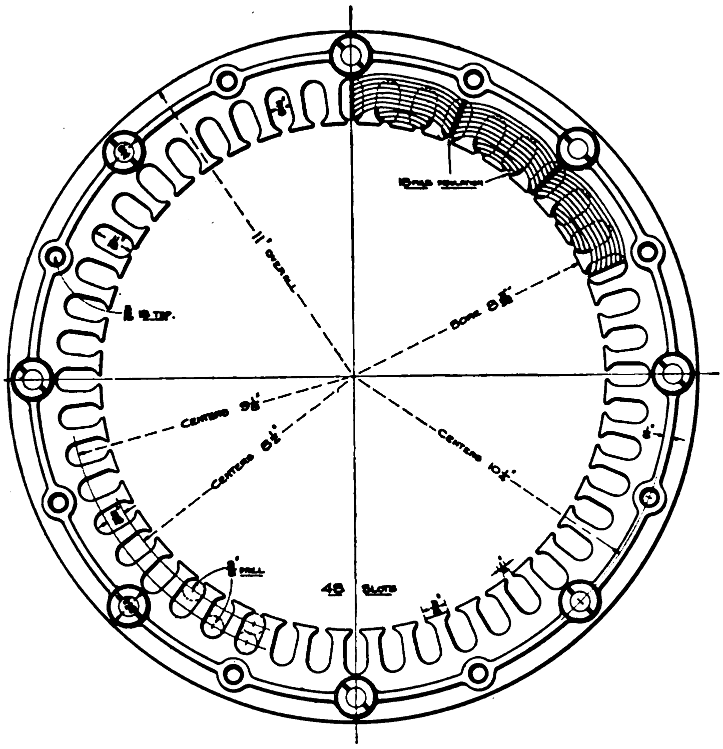


FIG. 1.—END OF STATOR.

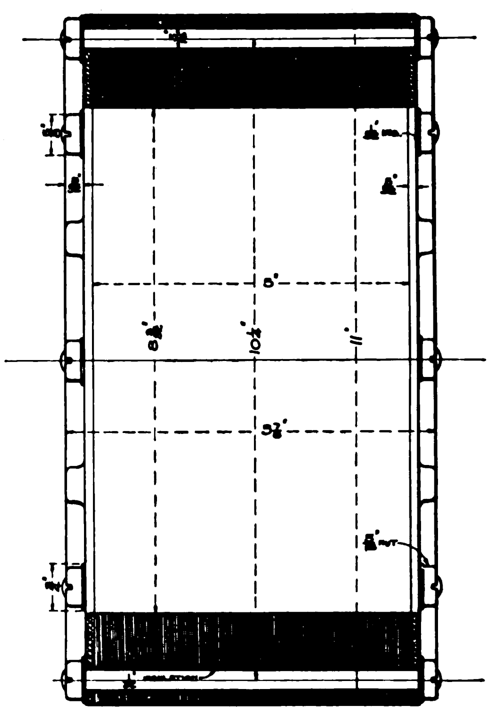


FIG. 2.—AXIAL SECTION OF STATOR.

Fig. 1 is an end view of the primary or stator core, showing the shape and size of the slots, and also showing three coils in position. The shape of slot employed has the advantage that it does not need to be punched out, but may be made by drilling two holes and filing away the intervening metal. By this method plain round discs may be used, and for tooling out the slots these are firmly clamped between two cast-iron flanges about 1 in. thick. One flange must be provided with 48 ⅜-in. holes, drilled at equal distances around a circle 8½ ins. in diameter, and the other flange has a similar series of holes drilled around a circle 9⅛ ins. in diameter. These holes form the two ends of one slot, and the metal projections where the arcs of the two circles meet must be filed away. The thin bridge of metal separating the slot from the air-gap is to be filed out also and the edges slightly rounded. While the discs are still held between the clamps the eight ⅜-in. holes should be drilled for the rods which hold the structure together. These are of 5/16-in. cold-rolled steel, 6 ins. long, with a screw thread and special nut on each end. The core punchings are held together by a pair of light brass end plates, which are preferably cast with slots in them to match those in the stator and with round edges. There are 48 slots in the stator, each ⅜ in. wide and 11/16 in. deep. Fig. 2 is a sectional view through the stator core structure parallel with the shaft, showing the arrangement of the clamping rods and end plates. It should be remembered that these clamping rods must be thoroughly insulated from the core laminations and from the end plates. If they are not they will form a closed secondary which will be disastrous to the operation of the motor.

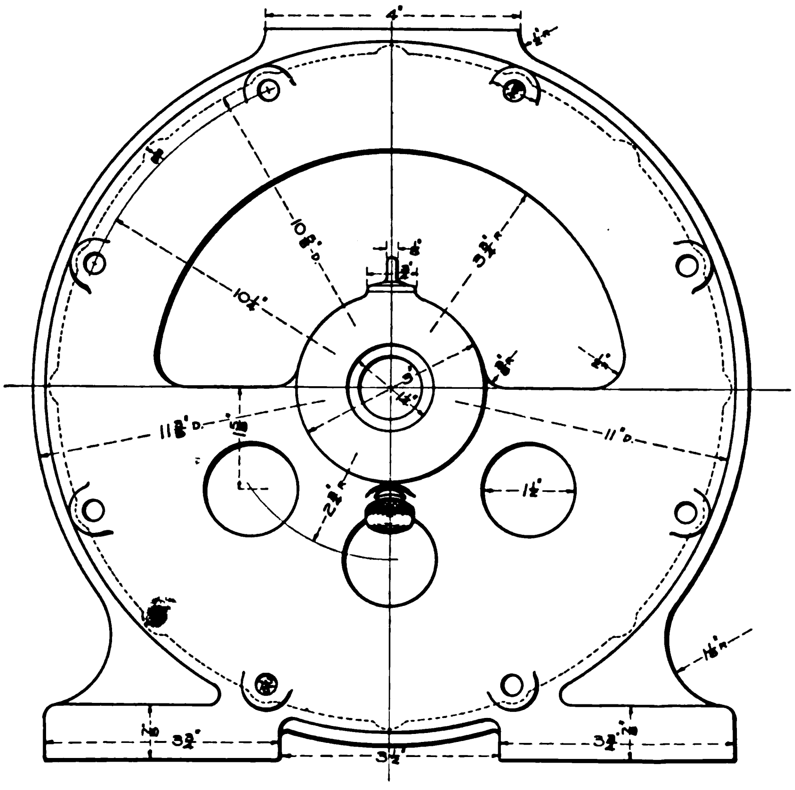


FIG. 3.—COVER PLATE OF MOTOR.

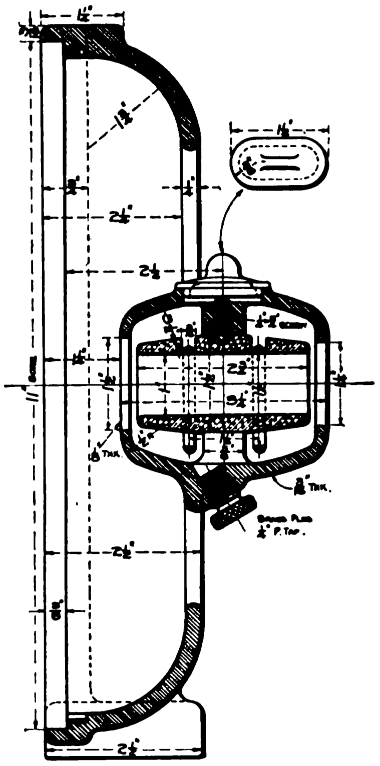


FIG. 4.—SECTION OF COVER PLATE AND BOX.

Fig. 3 is an elevation of the cover plate, and Fig. 4 is an axial section through this plate and the journal box which is integral with it. The cover plate is of cast iron and the exterior shell of the journal box is cast solid with it, the bushings being set in afterward. The plate is provided with ventilating openings and is recessed at the back, as indicated by dotted lines, to allow it to fit snugly against the stator core. It is fastened in place by eight 5/16 x 1¾-in. hexagon cap screws which tap into corresponding holes in the brass clamping plate of the stator. It will be noticed that the bearing shown in Fig. 4 is slightly different from those shown in previous designs; a small peep-hole, closed by a cover, is provided at the top and a screw-plug at the bottom, by means of which the bearing may be drained of oil and the supply renewed. The sleeve or bushing and the oil rings should be made of a good quality of brass, or, still better, of phosphor bronze. The only machine work necessary on this casting is to bore out the center of the journal-box shell to the diameter indicated and bore the recess in the ends 11 ins. in diameter to a depth of ⅜ in., so that the cover plate will just slip over the punchings of the stator core.

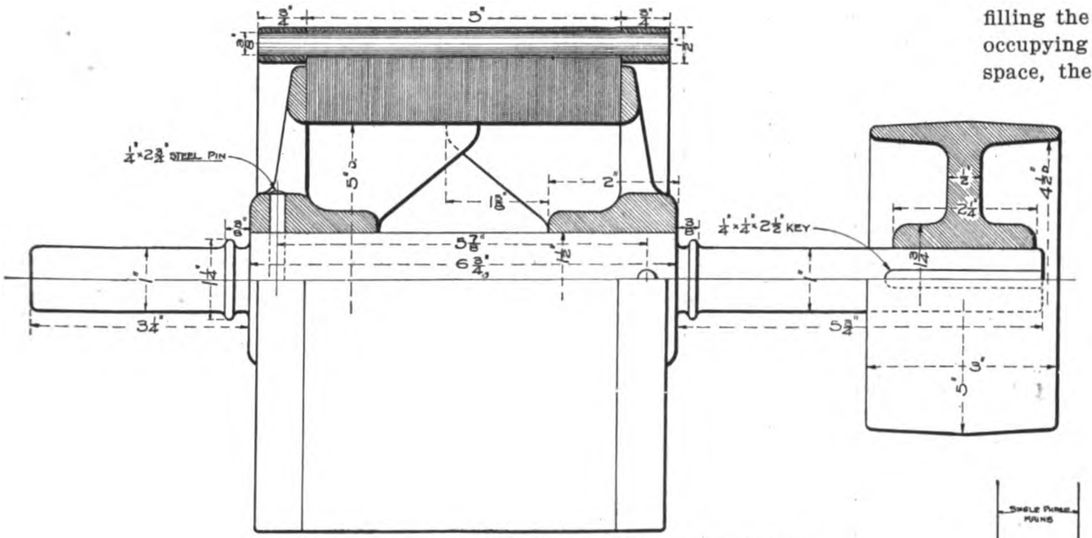


FIG. 5.—AXIA SEOLTION THROUGH ROTOR AND PULLEY.

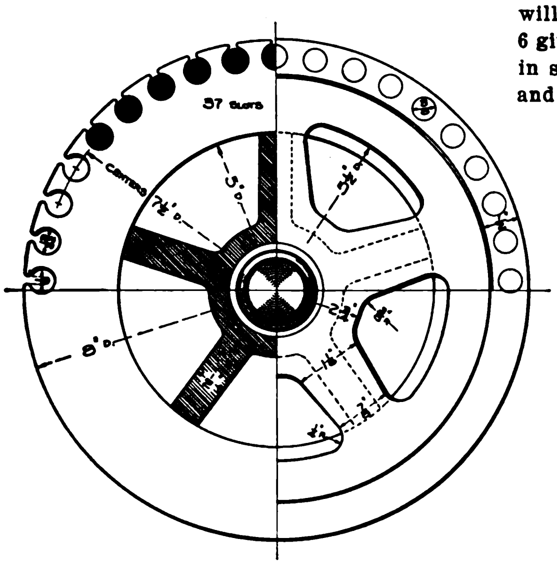
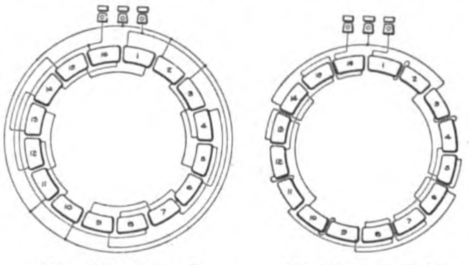


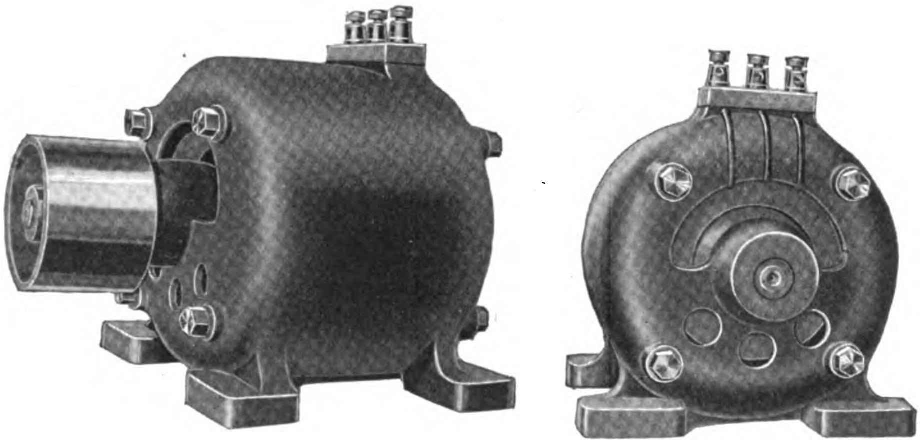
FIG. 6.—END OF ROTOR.

Fig. 5 shows the shaft and axial section through the rotor and pulley. The core is built up of laminated iron in the usual manner, the discs being 8 ins. in outside diameter, with a 5-in. hole in the center. The core discs are supported on two 5-arm cast-iron spiders, which are secured to the shaft by means of ¼-in. steel pins. Ventilating openings are provided in the end flanges of the spiders to allow a circulation of air through the interior of the core. The armature shaft is intended tc be made of 1½-in. cold-rolled steel, and will then require very little turning. Fig. 6 gives an end view of the armature partly in section to show the details of the slots and conductors. The discs are drilled with 37 slots 13/32 in. in diameter, and the conductors are composed of ⅜-in. copper rods each 6½ ins. long. All the conductors are connected in parallel through heavy copper rings at the ends.



100 volts; 125 cycles. 100 volts; 60 cycles.

FIG. 7.—STATOR CONNECTIONS.



FIGS. 9 AND 10.—SIDE AND END VIEWS OF COMPLETE MOTOR.

The primary winding for this motor consists of 16 coils of No. 13 B. & S. gauge double cotton-covered magnet wire, 30 turns per coil, each full slot containing 20 wires. The ends of the stator core and the interior slots should be insulated with cotton cloth or oil paper, put on with orange shellac varnish. Each coil is begun by filling the slots on each side of the tooth occupying the center of the total coil space, then the winding is continued in the adjacent slots on each side until these are half filled. A coil thus completed should have 30 turns of wire, which will put 20 wires in each full slot. It is not necessary to have precisely this number of turns; a slightly greater or smaller number will answer, but it is absolutely necessary that all of the coils shall have precisely the same number of turns. After the coils have been wound they are connected as shown in the diagrams, Fig. 7, which give the arrangements for the more common voltages and frequencies. Several other connections are possible for operating at higher or lower voltages, and any number of poles, such as 4, 8, 16 and 32, may be obtained by methods which may be easily devised by the builder, should the occasion require it.

This machine is designed to be started by means of a phase-splitter, and for this purpose three terminals are provided, the

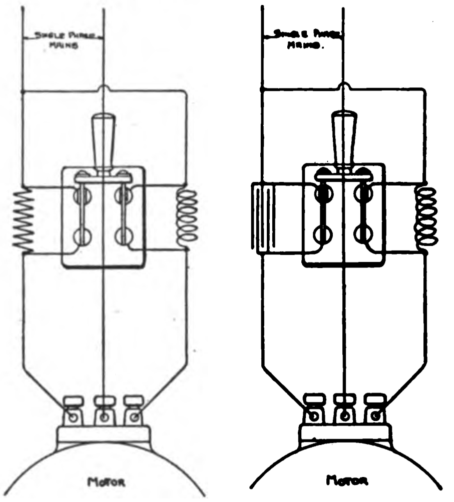


FIG. 8.—PHASE-SPLITTERS.

full line potential being applied between each outside terminal and the middle one, and the phase-splitting device suitably connected to the three leads as shown in Fig. 8. The phase-splitter would ordinarily be adjusted to take from 25 to 30 amperes on a 100-volt circuit, and it would then start the machine with about one-half the full-load torque.

The following is a brief summary of the important dimensions of the motor, and also the data for winding:

Two-horse-power motor; 4 and 8 poles. 1800 r.p.m. at 60 cycles; 1875 r.p.m. at 125 cycles.

Efficiency, 80 per cent. Power factor, 75 per cent at full load.

Total current at full load =

$$\frac{2 \times 746}{\text{E.m.f.} \times .75 \times .80}$$

= 50 amperes at 50 volts, or 25 amperes at 100 volts.

Rotor 8 ins. diameter and 5 ins. long. Peripheral velocity about 4000 ft. per minute.

Bore of field, 8 3/32 ins.; 48 primary slots, each ⅜ in. x 11/16 in.

Primary wire No. 13 B. & S.; diameter (double cotton-covered), 82 mils; cross-section, 5178 circular mils; 825 circular mils per ampere at full load; 16 coils; 30 turns per coil; 20 wires per slot. Weight of primary wire, including insulation, = 8.3 lbs.

Total lines of maximum flux per pole, 150,000. Cross-section of stator core body, 5 x 1½ ins. Maximum density in stator core, 20,000 lines per square inch.

Number secondary slots, 37. Cross-section of secondary conductors =

$$\frac{\dfrac{11 \times .0722^2}{4} \times 48 \times 30}{37} =$$

.105 sq. in., corresponding to ⅜-in. copper rod. Total length of secondary conductors, 20 ft. Weight of secondary conductors, 8 lbs. Weight of conducting rings, 2.8 lbs.

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ELECTRICAL HORSE-POWER.

The accompanying table, the construction of which is obvious, will be found handy in motor testing for the purpose of determining the ratio between the intake and output of the motor in horse-power. Its use obviates the bother of multiplying the current flow through the motor by the line voltage and resolving this into horse-power, which, while a perfectly simple operation, is, nevertheless, somewhat troublesome.

The figures in the body of the table give the horse-power corresponding to the voltage at the top of the table and the current given by the figures in the first column. For intermediate values of current not given by the table, interpolations are easily made decimally. For example, at the top of the table the horse-power corresponding with ½ ampere and 1 ampere, respectively, is given; should the current flow, for example, be 21 amperes at 220 volts, it is only necessary to add the horse-power corresponding to 1 ampere to that corresponding to 20 amperes, thus: .3 + 5.9 = 6.2 horse-power. For currents below 10 amperes the horse-power values may be obtained by considering a decimal point inserted between the two figures in the ampere column and moving the decimal point in the body of the table one figure to the left.

Amps.	Volts: 110	115	220	230	500
½	.073	.077	.15	.155	.33
1	.147	.154	.3	.31	67
10	1.47	1.54	2.95	3.08	6.7
11	1.62	1.7	3.24	3.39	7.37
12	1.77	1.85	3.54	3.7	8.04
13	1.92	2.	3.83	4.01	8.71
14	2.06	2.16	4.13	4.32	9.38
15	2.21	2.31	4.42	4.62	10.05
16	2.36	2.47	4.72	4.93	10.72
17	2.51	2.62	5.01	5.24	11.39
18	2.65	2.77	5.31	5.55	12.06
19	2.8	2.93	5.6	5.86	12.73
20	2.95	3.08	5.9	6.17	13.4
22	3.24	3.39	6.49	6.78	14.75
24	3.54	3.7	7.08	7.4	16.09
26	3.83	4.01	7.66	8.02	17.43
28	4.13	4.32	8.26	8.64	18.77
30	4.42	4.62	8.85	9.25	20.11
32	4.72	4.93	9.44	9.87	21.45
34	5.01	5.24	10.03	10.48	22.79
36	5.31	5.55	10.63	11.1	24.13
38	5.6	5.86	11.21	11.72	25.47
40	5.9	6.17	11.8	12.33	26.81
44	6.49	6.78	12.98	13.57	29.49
47	6.93	7.25	13.86	14.5	31.5
50	7.37	7.71	14.75	15.42	33.51
55	8.11	8.48	16.22	16.96	36.86
60	8.85	9.25	17.7	18.5	40.21
65	9.58	10.02	19.17	20.04	43.57
70	10.32	10.79	20.64	21.58	46.92
75	11.06	11.56	22.12	23.12	50.27
80	11.8	12.33	23.6	24.66	53.62
85	12.53	13.1	25.07	26.21	56.97
90	13.27	13.87	26.54	27.75	60.32
100	14.75	15.42	29.5	30.83	67.02

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REPAIR SHOP NOTES.

BY ARTHUR B. WEEKS.

The most vital part of an electric motor, and frequently the most abused, is its commutator. In street railway shops the writer has seen armatures up-ended and commutators driven on with a sledge-hammer; and time and again have the commutator shells been cracked and often irremedially ruined. After a few days of service the majority become loose, and the chances are that another will not fit the shaft. It is then usually necessary to put in a new armature shaft, yet the obsolete make-shift is frequently used as a last resort—that of prick-punching the shaft all around and thus increasing its diameter. To do good work, however, a hammer should never be used. Procure two steel rods of suitable length and diameter, and, placing a strap of stout iron with holes for the rods across the far end of the shaft and a similar strap across the commutator, force the commutator on by screwing up the nuts on the rods. By similar means armature shafts are replaced, but in most cases the commutator must be disconnected and also removed. Each style of motor has a different commutator construction, but none is difficult to remove after understanding the locking devices. Generally holes are drilled and tapped to apply the rods for removing the commutator. Place the strap of iron across the armature shaft at the near end, and draw up on the nuts.

Driving on pinions in a cold shop during the winter months has caused many an armature shaft to break. Screws securing a commutator or spider are also frequently sheared off during the process. A pinion should always be heated, whether it has a straight or a taper bore, before driving it on. Learn to use a pair of calipers intelligently in fitting pinions and commutators.

When a commutator is in place and securely fastened, the shell properly insulated and the leads all in place, another often-abused operation takes place, viz.: soldering in the leads. The writer has seen strong muriatic acid used in such work, and pounds of solder where ounces would have been better. Get the work hot and sweat the solder in. Use regulation flux, and very sparingly.

In a certain shop the writer once watched an armature winder repairing a short circuit in an armature, and berating his "luck"; for he said that that was the third time he had repaired it, and he didn't suppose it would do any good now! He used acid and solder both with great liberality. Both flowed down back of the bars occasionally, but he said he supposed that did no harm! Several segments had the mica burnt half an inch deep between them, and were left to run in that condition. What wonder there was a daily report that a certain car was blowing fuses and its motors running hot? Such a car is usually late, and in the rush to make up lost time, matters become even worse. But this repair man was fortunate if his armature got out of the barn after such treatment, there being no testing of any kind, with either a voltmeter or a magneto.

It is so easy to put jumpers on a commutator that frequently there are several put on and no heed paid to the deep cavities between bars, caused by a break in the circuit.

For the benefit of those not expert in the use of a soldering iron, the following hints will not come amiss: First, get the work ready, with all joints clean and secure. If charcoal is used, have a good, clear fire; if gasoline, regulate the flame for a steady, even temperature, so that the irons may neither cool nor need frequent tinning from overheat. Have as many irons as are required to keep things going. Next, have the proper soldering fluid or paste, as the case may be, some makes being better adapted to certain lines of work than others, as can be proved only by trial. Rosin, either dry powdered or dissolved in grain alcohol, does well for new work, especially on commutators, while a number of pastes, such as Paragon and Highland, Post Glover, and others, have the advantage of greater adaptability. Never use a blow-lamp on small work in soldering commutator connections; it may be used on large work, but is a dangerous tool in inexperienced hands.

In soldering vertical conductors of specially constructed armatures or bus-bars, paste is best, since it will not run down over the work. In this kind of work, asbestos should be packed below the joint to be soldered, to catch the surplus solder, and mica or asbestos used to protect conductors contiguous to the joint being made. A solution recommended by the underwriters is perhaps the best for all around work. It consists of 5 parts saturated solution of zinc; 4 parts alcohol, and 1 part glycerine. In splicing cables under a car, however—where, especially in wet weather, every part is thoroughly saturated with moisture—the work is done under great difficulties. Sometimes, no matter how clean a wire is made, a black substance forms upon it under heat, when nothing but a strong soldering fluid will make a good joint. Add muriatic acid to the above solution for such joints, and wipe off thoroughly afterward.

Night men especially seem to think a good connection consists in the abundance of solder used, and often a splice many times the proper size is found taped over which on inspection proves loose. Some men depend entirely upon solder in making a splice under a car, instead of the proper twisted connection first. This is certainly poor judgment.

Special shaped irons are required for some classes of work. An armature winder was once accused of using a blow-lamp on a street railway commutator, because the segments fell in, and shellac oozed from the mica between the bars when soldering. It was a re-filled commutator, which proved to be of cast soft copper, with the built up mica saturated with fresh shellac. However, after connecting and baking thoroughly, it was put on trial, with nuts tightened before and after baking. This must never be neglected. The trial did not last long, for the commutator burnt out from excessive sparking, and was a constant source of trouble as long as it lasted. One sample of a cheap commutator is all any company cares for. The very best is none too good.

The following experience in repairs on a 500-h.p. railway generator armature will aid anyone undertaking such a job. The commutator was all right—good for several years to come, but was to be disconnected and removed from the shaft and the armature re-wound. Blow-lamps were used, and a strong soldering fluid applied very freely. The new coils were put in place, and the commutator tested with a 220-volt circuit, when the lamps showed full candle-power between the majority of the segments. Sandpaper was used, and the mica between the segments was scraped with scratch-awls; still there was trouble. One man had six inches of a hack-saw blade between a couple of bars at the lower rear end of the commutator, and another used a knitting-needle for the same purpose. And so it continued for several days, the holes being filled with melted sulphur; finally it tested clear. When the armature was ready it was put into service, but there was excessive sparking and a few days later a great hole was burnt in the commutator to the iron shell. This was repaired and the machine tried once more, but with no better results; so a new commutator was put on, after which there was no further trouble. This time, however, large soldering irons were used instead of blow-lamps, and the acid was applied more sparingly, which was undoubtedly the secret of it all. The other commutator was torn apart and will be rebuilt, as there are several years of wear in it still.

THE CONTROL OF LIGHTS FROM MORE THAN ONE POINT.

BY R. M. VAN VLEET.

As incandescent lamp users are well aware, it frequently occurs that to control a lamp or group of lamps from two or more points is not only extremely convenient but almost necessary. This is particularly true in the case of residence lighting, where it is desirable, for example, to be able to control hall lamps from either the lower or the upper floor of the house. It is not the writer's intention, however, to enumerate the places in which multiple control is advantageous, but merely to suggest a few methods of wiring lamps for such control.

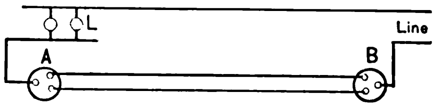


FIG. 1.—TWO STATIONS.

It is commonly known to wiremen that a lamp or group of lamps can be readily connected up for control from two points, but it is not so generally known that the control can be extended to three, four, or any number of points without serious complication in the way of switches. The accompanying simple diagrams illustrate methods of wiring for two-point, three-point and four-point control.

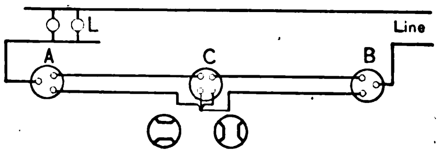


FIG. 2.—THREE STATIONS.

Fig. 1 shows the two-point control, in which the lamps, L, may be turned off and on by three-point switches at A and B. Fig. 2 shows a similar arrangement in which an intermediate four-point switch, C, is inserted, giving three controlling stations. The two circles in the lower part of the diagram illustrate the two positions of the four-point switch. Fig. 3 shows a four-station arrangement, which is obtained by inserting another four-point switch, D. This arrangement may be indefinitely extended by adding four-point switches, it being only necessary to have a three-point switch at each end of the switching circuit and the proper number of four-point switches in between.

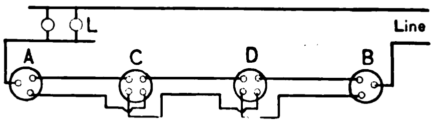


FIG. 3.—FOUR STATIONS.

INTERIOR WIRING.

BY CHARLES E. KNOX.

The wiring of the thirty-two-story Park Row building will be the subject for consideration in this article. This building is said to be the tallest building in the world. As will be seen from the diagrams, the building is irregular in shape, and consists of cellar, basement, twenty-five full stories and seven partial stories. Its approximate cubical capacity is about 3,000,000 cubic feet. The building is, of course, of fireproof contruction. The partition walls are of 4-in. terra-cotta blocks. The floor construction consists of the usual flat terra-cotta arches; the flooring is double and laid on 3-in. wooden sleepers resting on top of the beams. This leaves a space of 3 ins. between the tops of the beams and the under side of the rough flooring; this space is utilized for running the conduits.

Figs. 1, 2 and 3 show the wiring of characteristic floors. The floors from the second to the twenty-fifth, inclusive, are almost identical in every respect, and consequently the wiring of one of these floors will show the features of all of them. The wiring includes both power and lighting circuits. The power wiring is a considerable factor, as all of the ten elevators are driven by electric motors. There are also several large electric ventilating fan motors. The lighting-circuit work will be considered first.

LOCATION OF OUTLETS.

The remarks made in the previous article relating to the outlets in the cellar of that building apply with equal force to the outlets in the cellar of this building.

The lighting in the hallway entrances in front of the elevators and over the booths or small stores in the halls on the first floor consists of single-receptacle lights arranged symmetrically, as shown, in the ceiling. These receptacle lights are placed in plaster rosettes which form part of the ceiling design. The lighting of the remaining or store portion of the first floor is purely general in character and is obtained almost entirely by means of chandeliers, as shown in Fig. 2. On this floor one 16-c.p. lamp serves to illuminate about 550 cu. ft. Means has been provided for window lights at the front end of the building. This consists of two cut-out panels placed under the two windows and supplied by special mains.

The arrangement of the outlets in the offices on the upper floors is practically the same at all floors and consists of a chandelier outlet and two side-bracket outlets in each office. The hall lighting is obtained entirely by means of chandeliers.

There are two chandelier outlets in the large toilet room and one in the small toilet room on each floor. A single ceiling light is provided in each of the passenger elevators. In the offices one 16-c.p. lamp is allowed for about 500 cu. ft. In the halls one 16-c.p. lamp has been allowed for every 600 cu. ft.

BRANCH CIRCUIT WIRING.

From the basement to the twenty-sixth story the lights serve two purposes, office lighting and hall or public lighting. There are no hall lights in the cellar or in the six upper stories. The lights in the cellar are wired on branch circuits originating at the two centers of distribution. The statements made in relation to the wiring of the cellar lights in the building which was the subject of the last article also apply to the wiring of the cellar lights in this case. Five centers of distribution serve to supply the branch circuits for the basement lighting. Four of these centers serve for the room or general lighting and one for the hall lighting.

At the first floor there are thirteen centers of distribution, seven of which serve for several lighting and six for hall lighting. These centers of distribution are located at six points, two or more of the distributing boards being usually placed in the same cabinet. Thus, at one point there are two groups of cut-outs for the halls and two for the offices. Each group is supplied and controlled separately, as is explained hereinafter under the head of Feeding System. As will be seen from Fig. 2, each branch circuit supplies not less than four nor more than eight lights. All of the ceiling outlets are controlled by switches placed on the wall, in the case of the room lighting, and in the cabinet containing the various cut-outs, in the case of the hall lights. It will be noticed that the hall lights are wired alternately, one-half of a group or row being connected to one branch circuit, the other half or group being connected to a second circuit. These branch circuits in turn are divided between the two sets of hall-lighting centers of distribution. The two chandeliers at the main entrance are supplied by two circuits, one of which supplies four lights at each chandelier, the other circuit supplying the remaining lights.

At the upper or office floors the arrangement of the branch circuits is very simple. The chandeliers and bracket fixtures are wired throughout on separate circuits, as shown in Fig. 3. None of the lights in the offices are controlled by switches, the lamps being turned on and off by the key sockets at the fixtures. The number of lights wired to one branch circuit varies from five to nine. The outlets in the halls are wired in alternation, so that every other fixture is connected to one set of distributing centers and the remainder are connected to the second set. Each circuit is controlled by a push-button switch at the distributing center at which said circuit originates. The bracket outlets on the landings of the stairs are fed by vertical circuits, originating at every fifth floor. Thus, a circuit starting at the second floor supplies the outlet on the stairs at that floor, and, rising vertically, supplies the outlets at the same point on the third, fourth, fifth and sixth floors, inclusive. Separate circuits are run for the outlets in the two toilet rooms. Each of these circuits is controlled by a switch located at the center of distribution. These circuits are connected to the room or office lighting system, as it sometimes occurs that the lights are needed when the hall lights are not required.

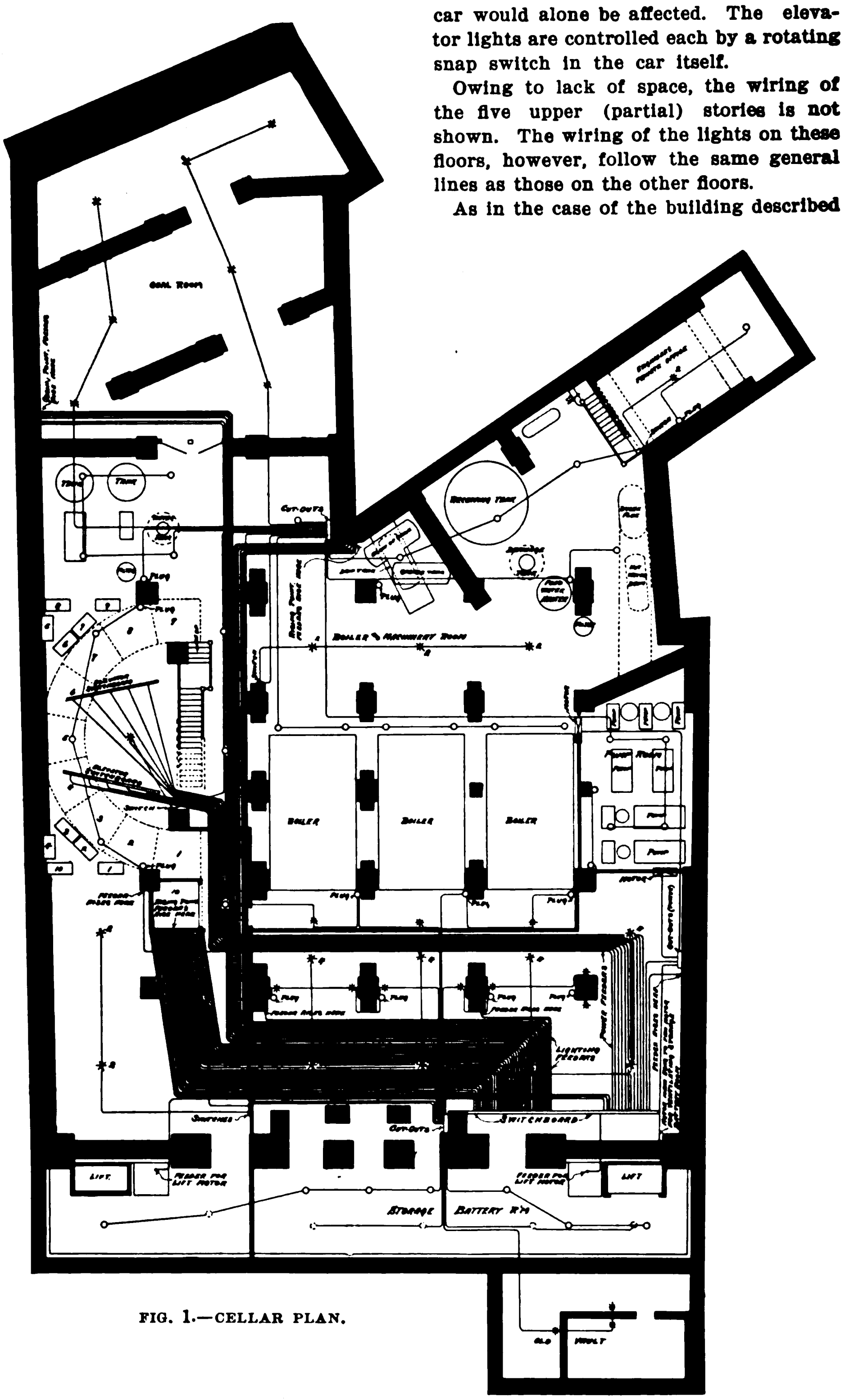


FIG. 1.—CELLAR PLAN.

An attachment plug is located at every floor in each of the two shafts back of the elevators. These attachment plugs serve for obtaining a movable light (by means of a flexible-cord connection) for the purpose of examining the elevator machinery. These plugs are wired on vertical branch circuits in the same manner as the outlets on the staircase landings. Each of the lights in the elevator cars is wired on a separate branch circuit, so that in case of trouble on any one of the elevator cables the light in the corresponding car would alone be affected. The elevator lights are controlled each by a rotating snap switch in the car itself.

Owing to lack of space, the wiring of the five upper (partial) stories is not shown. The wiring of the lights on these floors, however, follow the same general lines as those on the other floors.

As in the case of the building described in the previous article, separate and distinct feeders are provided for the office lights and for the hall lights. In this case, however, the hall lighting is a much greater factor, and therefore requires special treatment. In order to give the engineer complete control of the hall lights, two sets of feeders are provided for them. It frequently happens that on dark days the sunlight coming from the offices through the glass in the doors and transoms is not sufficient to light the halls properly and it is necessary to throw on part of the hall lights. This is most readily done in the manner described hereinafter.

Fig. 4 shows the general arrangement of the feeders, mains and the distributing centers. In this figure the distributing centers are designated by circles having the letter *H*, *O* or *P*, inscribed inside the circle. These letters indicate that the distributing center serves to supply circuits for hall lighting, office or other general lighting, and for power purposes respectively. Two or more circles representing distributing centers, shown close together indicate that the cut-out panels serving for these centers are located in the same cabinet. The two distributing centers in the cellar are supplied by a feeder which connects with one of the centers and is prolonged by a main to the second center.

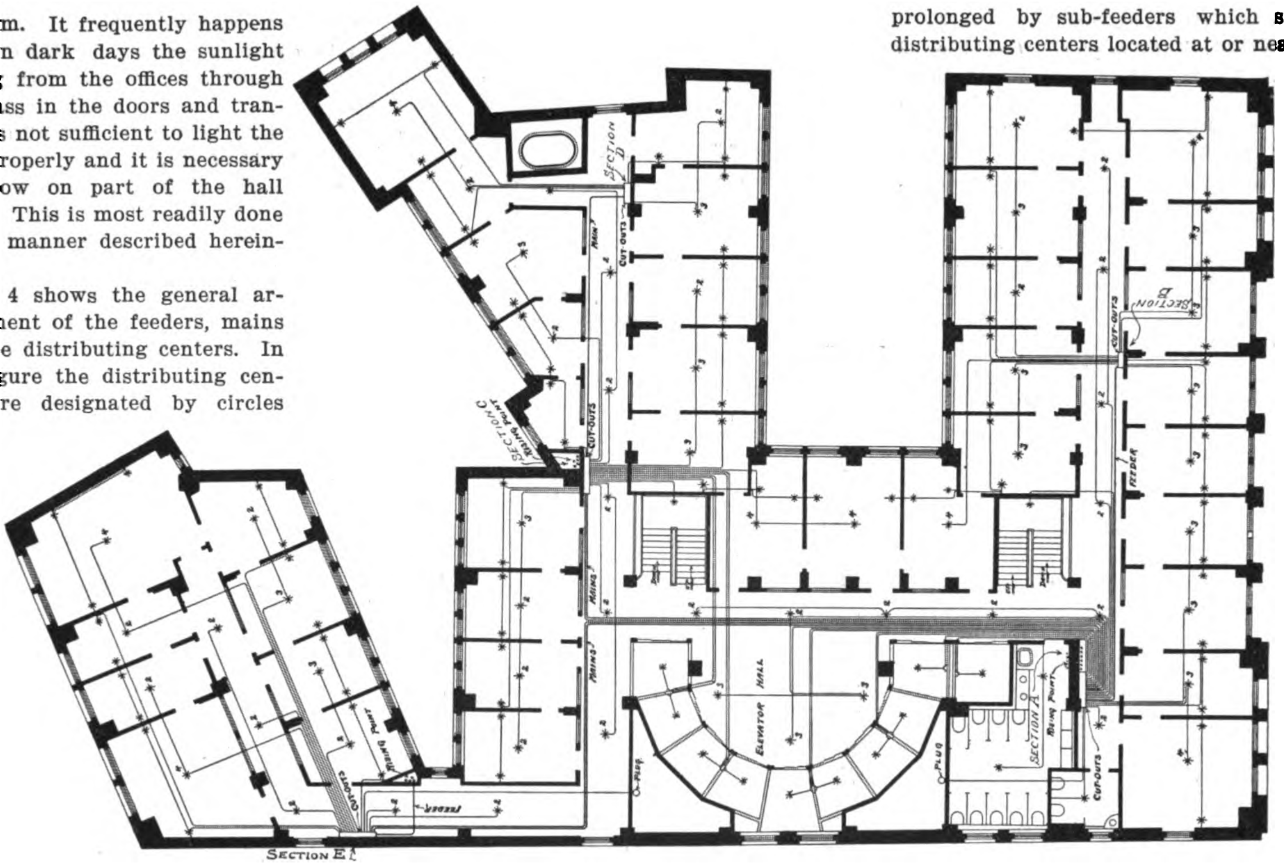


FIG. 3.—WIRING PLAN OF THE UPPER FLOOR.

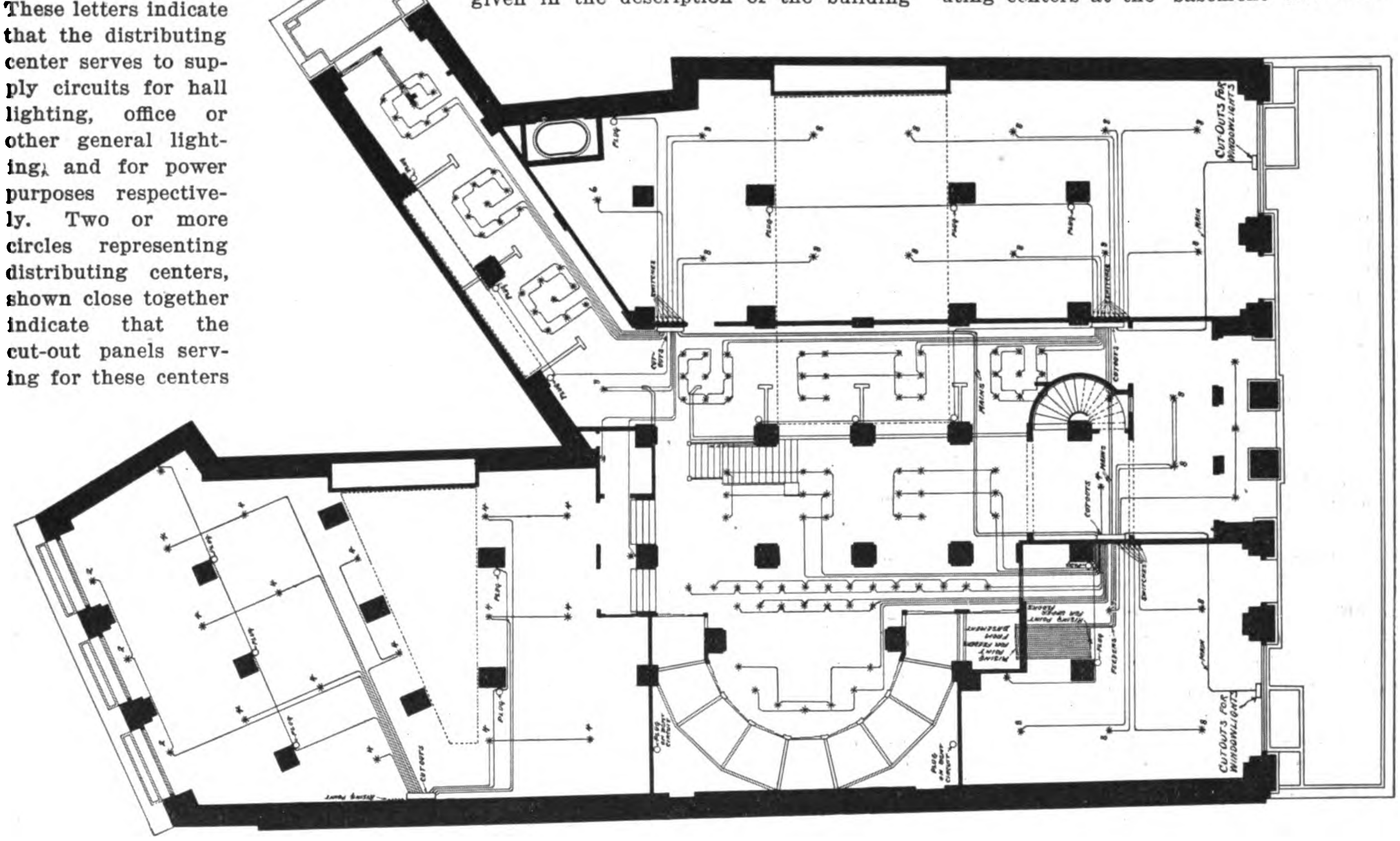


FIG. 2.—WIRING PLAN OF THE FIRST FLOOR.

This feeder does not supply any lights at any of the other floors for the reason given in the description of the building in the last number. All the floors above the cellar are supplied by a vertical system of feeders and sub-feeders; that is to say, the feeders extend to certain floors at which they terminate and thence are prolonged by sub-feeders which supply distributing centers located at or near the same points at the floors above and below the feeding point. Thus the distributing centers at the basement and first floors and part of those on the second floor are supplied by feeders extending to and terminating at the first floor.

From the second to the twenty-fifth floor, inclusive, the building is divided into five electrical sections, designated by the letters *A*, *B*, *C*, *D* and *E* (see Figs. 3 and 4). At each of these sections there is a distributing center serving for the branch circuits for office lighting. There are centers serving for the hall lighting circuits at three of these points only (sections *A*, *C* and *E*) as the number and arrangement of the hall circuits did not make it necessary to have a center at each of the five points. There are rising points for the feeders at three of the five sections for office lighting but at only one of the sections for hall lighting. (One of these rising points serves for a double set of feeders.) It will also be seen from Fig. 4 that the second to the twenty-fourth floors, inclusive, are divided into groups of five floors each. For example, the floors from the twelfth to the sixteenth floor, inclusive, are supplied by feeders terminating at the fourteenth floor. In similar manner the fourth, ninth, nineteenth, and twenty-fourth floors are feeding floors, and the centers at the two floors above and below these stories are supplied by sub-feeders forming prolongations of the main feeders.

As stated above, the feeders for the hall lights rise at one point only, (section *A*) because the number of the hall lights did not warrant running a separate set of feeders for each set of the hall centers. Thus, at the twelfth floor, the two feeders for the two sets of hall lights terminate at the centers at section *A*. From this point vertical sub-feeders extend to the corresponding hall centers at the two floors above and below. From this point also, horizontal sub-feeders are extended to the centers for hall lights at sections *C* and *E;* these in turn are extended by vertical sub-feeders to the centers at the same relative points at the two floors above and below. The feeders supplying the centers for office lighting rise at three points at or near the distributing centers at sections *A*, *C* and *E*. The centers for office lights at section *D* are supplied by horizontal sub-feeders (at the feeding floors) from the centers at section *C* in a similar manner to the hall lighting system.

The twenty-sixth floor being a partial story, there are but four distributing centers for lighting purposes. The centers in the tower stories (twenty-seven to thirty-second inclusive) are supplied by a feeder terminating at the twenty-seventh floor. A second feeder terminating at the twenty-seventh floor serves to supply circuits for outside lights on the dome, at the level of the thirty-first floor.

RISING POINTS.

There are three main rising points for the feeders located near sections *A*, *C* and *E*, as shown in Fig. 3. The rising point in section *A*, in addition to serving for the feeders supplying the centers in this section, also serves for the feeders supplying the centers in section *B*, the feeders being run horizontally across the floor at each of the feeding floors, from this point to section *B*. These rising points consists of chaces built into the walls of the building for the purpose.

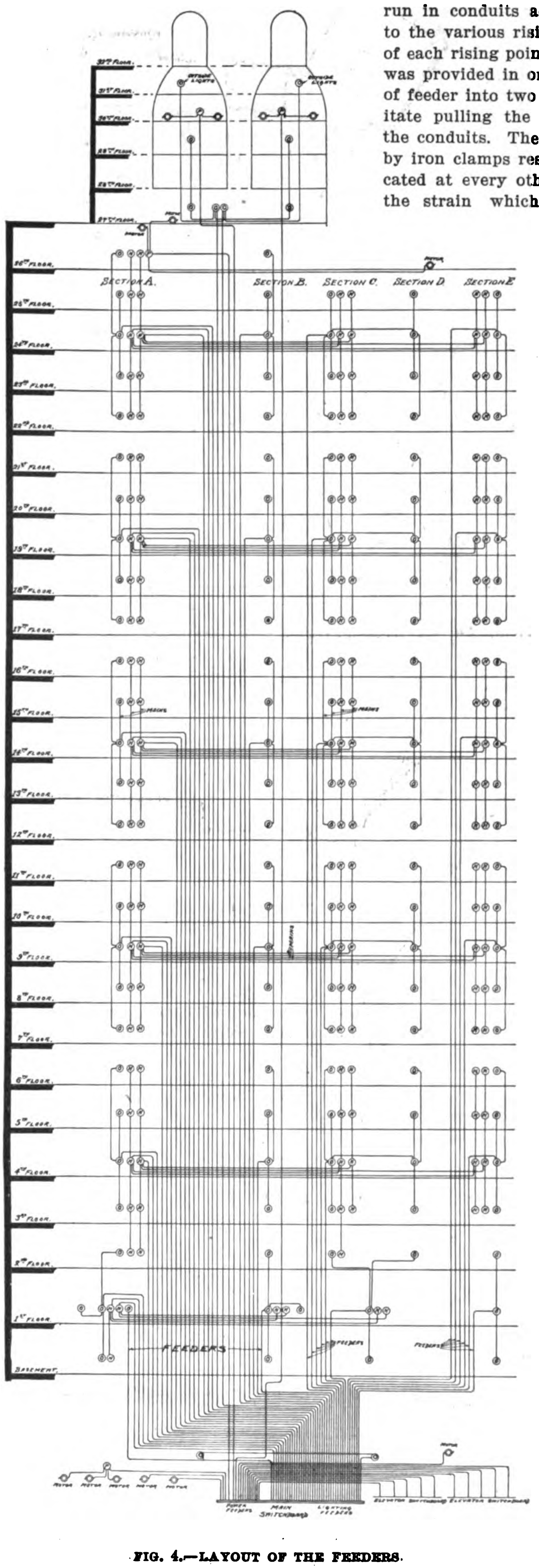


FIG. 4.—LAYOUT OF THE FEEDERS.

As will be seen from Fig. 1, the feeders run in conduits across the cellar ceiling to the various rising points. At the foot of each rising point a junction or pull box was provided in order to "break" the run of feeder into two sections, so as to facilitate pulling the feeder conductors into the conduits. The conduits are supported by iron clamps resting on angle irons located at every other floor, thus relieving the strain which would otherwise be placed on the couplings of the conduit. The feeder conductors in every case are securely fastened and supported at both ends of the vertical portion of the feeder.

POWER FEEDERS AND CIRCUITS.

Electric power is used for two purposes viz., driving ventilating fan blowers and for the ten electric elevators. The elevators are of the Sprague screw type, the screws being placed vertically in the shafts back of the elevators and the motors being located on the cellar floor. A separate feeder is run from the switchboard in the engine room to each of the ten elevator motors. The controllers for the elevator motors are mounted (in two groups) on two subsidiary elevator switchboards located in the cellar at the foot of the elevator shaft.

There are thirteen motors serving the ventilating blowers, six of these being located in the cellar, two on the twenty-sixth floor, one on the twenty-seventh floor, and four on the thirtieth floor. These thirteen motors are supplied by seven power feeders, the number of motors supplied by one feeder being determined by their size and their relative location. The feeders and circuits for the motors are run in conduit in precisely the same manner as those serving for lighting purposes. The conduits, wires, outlet boxes and panels were similar in this case to those described in the previous number for the building at 7 Wall Street.

PLANT.

The plant consists of four units aggregating 575 kilowatts capacity. The dynamos are direct-current compound-wound 116-volt machines, and are direct-connected to a high-speed compound non-condensing engines. The dynamo plant is supplemented and balanced by a storage battery of 2500 ampere-hours capacity. Two boosters are used for charging and for maintaining and equalizing the voltage; one is engine-driven and is of 40-kilowatts capacity, the other is motor-driven and is of 20-kilowatts capacity.

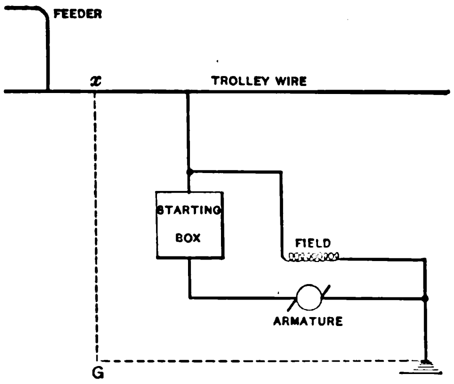
The switchboard consists of three panels, the middle panel serving for the generators and storage battery, the right-hand panel serving for lighting feeders, and the left-hand panel for power feeders. The specifications and plans for the entire electrical equipment were made by C. O. Mailloux, who also supervised the erection and installation of the work.

SHUNT-WOUND MOTORS ON RAILWAY CIRCUITS.

BY E. C. PARHAM.

Shunt-wound motors are often used in car-houses and repair shops to drive a line of shafting or some isolated machine. Men in charge of such motors have, no doubt, often noticed that at the same time that the shop lights go down or out on account of a ground-out on the line, the belt on the motor either squeals or flies off. It may have also been noticed that a series-wound motor running under the same conditions does not behave this way. This difference in behavior is due, in the first place, to the fact that a shunt-wound machine runs in the same direction as a dynamo that it does as a motor, the connections remaining the same, while a series-wound machine runs in opposite directions in the two cases. Consequently, if a shunt machine which is running as a motor be disconnected from the source of power and its terminals short-circuited, it will start to generate and come to a halt in short order, whereas a series machine under the same condition would not generate at all and would keep on running until the momentum of the armature and shafting was exhausted by friction.

Fig. 1 is a diagrammatic sketch of a shunt motor supplied from a trolley wire which receives current from the feeder shown tapped onto it. Now this feeder passes through a circuit-breaker at the power house, so that any excessive flow of current that takes place in the feeder, on account of a ground on the line or one on a car, as indicated by the dotted line, x g, will "throw" the circuit-breaker, and the section of trolley wire supplied by this feeder will be dead, as far as the power house is concerned. Suppose a ground to take place on a car or on the line at x (the grounding of a line on an iron bridge or in a conduit is not an unusual occurrence; in fact, on some roads two trolley wires are strung across such bridges, so that in case one grounds it can be cut out and the other one cut in); if the shop motor is running when the ground occurs, the momentum of its armature, together with that of the shafting and whatever machines may be fitted to it, will keep the whole outfit going awhile after the current is cut off.



MOTOR SHORT-CIRCUITED BY A GROUND.

As soon as the ground takes place at x, both ends of the motor armature and field are grounded, and the motor becomes a dynamo generating through a short-circuit, just as though the two outside terminals of the motor were held together by hand. The fields of the motor being fully excited, a large current flows through the local circuit and puts a drag on the armature. Now, when the machine was running as a motor, one side of the belt was tight, because the motor was pulling the shafting; but running as a dynamo, the other side of the belt will become tight, because the shafting is now doing the pulling. The drag due to the dynamo action under short-circuit is so suddenly imposed that the change in the relations of the two stretches of the belt comes in the form of a severe wrench, and the belt will probably be thrown off its pulley. If the belt does not go, one of two things will happen; the motor will lose its field, because a shunt dynamo cannot support a field on short-circuit, and come to a natural stand as soon as the momentum of the shafting is exhausted, or it will come to a very sudden stand because there is not power enough stored in the moving parts to drive the load caused by the large current flowing through the armature under short-circuit.

It is not necessary for a ground to occur in order to throw the belt or make it squeak. If there is a block on that part of the line fed by the feeder from which the shop motor takes its current, when the block is cleared, so many of the cars may try to start at once that the power house circuit-breaker will go out, leaving the line dead and the shop motor practically short-circuited by the low resistance path provided by the many car motors in multiple. And even if the circuit-breaker does not go out, should a temporary ground on a car or on the line or an excessive current due to too many cars trying to start at once, cause the voltage on the line in the neighborhood of the shop motor to drop below the e.m.f. that the motor, acting as a generator at its regular speed and field excitation, could generate, it promptly becomes a dynamo and tries to help out the power station by sending a current of its own into the line. Such action as this sometimes occurs several times in a day and it is usually announced by the squeak of the belt due to the slipping that takes place when the tight and slack sides of the belt exchange functions. None of these peculiar actions can take place with a series-wound motor, because that motor cannot generate under the conditions given. It should be borne in mind that the action takes place while the motor is at full speed and all of the starting resistance is cut out; moreover, while the details of the occurrence must be related in due sequence, they all really take place in such a short space of time that even if the motor is wired up to an automatic cut-out starting box, this device cannot act in time to wholly prevent the action described.

BOILER TUBE SCRAPERS AND BRUSHES.

BY JAMES F. HOBART.

Tube cleaners are so numerous that a single column of this page would scarcely contain the names of their makers. There are several kinds of types, the most common being that which simply scrapes the tube; while another class uses revolving wheels to cut the soot and scale from the iron, on the same principle that the revolving corrugated wheel cuts deeply into the surface of the grindstone during the trueing-up operation. Still another kind of cleaner uses a combination of wheel and scraper; another type works by blowing the dirt and soot out of the tube by means of a steam jet delivered by the cleaner. There are various combinations of the several types, some of considerable merit, others plainly "made to sell." There is also still another kind of tube cleaner, one designed for use on water tube boilers, which works somewhat like a twist drill, boring through the length of the tube and removing everything inside. Some of this class of cleaners are made automatic. They are operated by power, and some of them have to be set and guided by hand, while others will bore their way through a tube and then retreat and advance to the next tube.

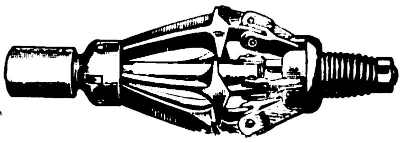


FIG. 1.—PHŒNIX SCRAPER.

The scraping class of tube cleaners is perhaps the most often found. Fig. 1 represents one of the class that may be adjusted to fit various sizes of flues, known as the Phoenix. The cutting or cleaning

action takes place only during the forward movement of the appliance, when the cutters expand, under the influence of the pressure applied, until they fit the tube, irrespective of the screw adjustment. This cleaner is made by the Hubbard Manufacturing Company, Buffalo, N. Y.

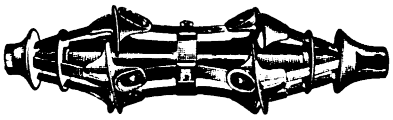


FIG. 2.—SHERWOOD DUPLEX SCRAPER.

Fig. 2 shows a tube cleaner of the same general principle which will act during both the outward and the inward strokes. It is made by The Sherwood Manufacturing Company, Buffalo, N. Y., and practically consists of two cleaners attached to the same central rod, with two adjusting screws. This scraper has the cutting blades arranged spirally so that the dirt and scale removed from the tube will pass between the blades and to the rear of the scraper, thus leaving the blades free from any obstruction due to the matter removed. Fig. 3 illustrates a telescopic scraper holder made by the same company. This is an excellent device where the room in front of a boiler is limited, as the handle may be lengthened or shortened while in the tube.

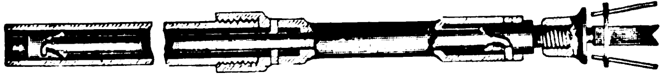


FIG. 3.—SHERWOOD SCRAPER HANDLE.

Fig. 4 represents the King scraper, made by the Michigan Lubricator Company, of Detroit, Mich. This tube scraper is also of the duplex variety, but a single screw controls both sets of blades and the scraper may be expanded or reduced while in the tube, so that if a heavy coating should be encountered, a light cut may be taken, then the scraper expanded and another layer taken off, and so on, until the tube has been cleaned down to the metal.

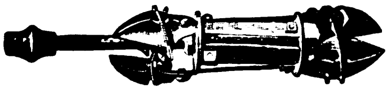


FIG. 4.—KING SCRAPER.

In the flue cleaner shown by Fig. 5 there are neither screws nor springs. The appliance is manufactured by T. D. S. Ruggles Company, Kent, Ohio; the central rod has a loose collar with slotted arms to which the scraper blades are attached. When the scraper is moved in either direction, a set of cutting arms will be thrown out by the pressure of the opposite set of cutters against the bell-shaped stationary collar at that end. In direct contrast with this scraper, which has no springs, is the one illustrated by Fig. 6, which is all spring. This cleaner is made by A. Christoffel, Brooklyn, N. Y., and is known as Christoffel's elliptic tube cleaner. It is merely a number of thin flat steel strips, held fast at either end, and expanded in the middle by screwing up a nut which presses the ends of the steel strips together, thereby enlarging their diameter in the middle. This scraper cuts both ways and is stiff, yet perfectly flexible.

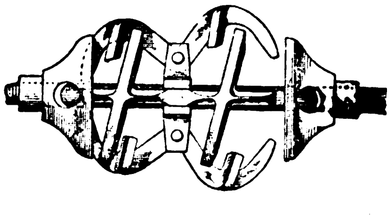


FIG. 5.—RUGGLES SCRAPER.

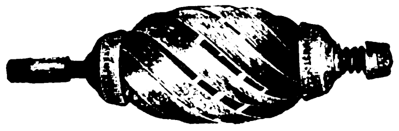


FIG. 6.—ELLIPTIC SCRAPER.

Fig. 7 illustrates a scraper marketed by the Crane Company, Chicago, Ill. This scraper is known as the "Jackson"; it is a spring scraper which can be further adjusted by a screw in the base. A scraper with a similar adjustment is the Globe, made by Veitus Radspinner, Peoria, Ill., and illustrated by Fig. 8. In this scraper the blades are made of steel, and are arranged to cut off the scale only when the tool is pushed forward. The cup-shaped washer at the end of the scraper is for pushing out the dirt and soot as fast as it is removed from the surface of the tube. Another scraper which is somewhat similar in design is shown by Fig. 9. This is called the Coggeshall scraper, and is made by Coggeshall & Hicks, Boston, Mass. The cutting edges are of chilled iron and it is claimed that they have unusually long wear. The springs are said not to break or anneal. The cutting edges are detachable without taking the scraper to pieces.

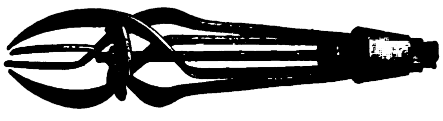


FIG. 7.—JACKSON SCRAPER.

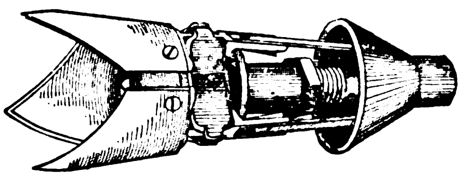


FIG. 8.—GLOBE SCRAPER.

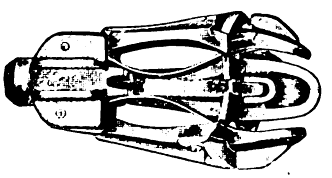


FIG. 9.—COGGESHALL SCRAPER.

Fig. 10 illustrates an improved flue brush, made by the Pilley Packing & Flue Brush Manufacturing Company, of St. Louis, one feature of which is its adjustability. The brushes are arranged in two groups, each group being divided into longitudinal sections. The sections of one group are staggered with relation to those of the other, so that the entire surface of the tube is swept by the brush. The diameter of the brush can be adjusted within reasonable limits by setting up the screw and nut which clamp the ends of the individual sections. Fig. 11 is a combination of scraper and brush, which is made by the same company. The brush is of the ordinary cylindrical type composed of radial wires which pass entirely through holes in the iron center piece and are fastened on the inside, making it impossible for the wires to come out. The size of the scraper is adjusted by twisting the iron rod which serves as a handle.

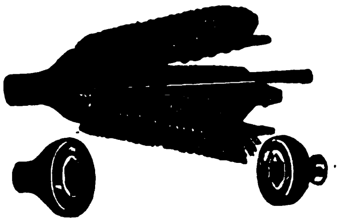


FIG. 10.—PILLEY EXPANSION BRUSH.

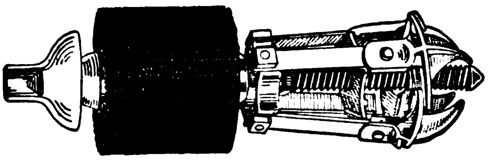


FIG. 11.—PILLEY COMBINED BRUSH AND SCRAPER.

Fig. 12 represents the Ingalls cleaner made by A. W. Chesterton, Boston, Mass., and like the Pilley combination tool, comprising a scraper and a brush in one piece of apparatus. The scraper is similar to that shown by Fig. 1, and the brush is practically like the one used on the Pilley combination cleaner. There is a spring in the casing of the scraper which is fully protected from dirt and allows the cutting edges of the tool to adjust themselves to any inequalities on the surface of the tube which they cannot remove.

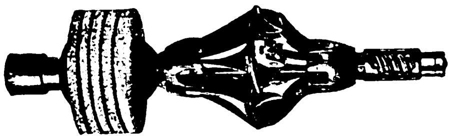


FIG. 12.—INGALLS SCRAPER AND BRUSH.

In addition to the types of scraper so far considered there are power-driven machines which include a revolving head carrying cutters and driven by a flexible shaft of some sort. This class was mentioned in the first paragraph of this article. Two forms of revolving-head cleaner are shown by Figs. 13 and 14, the principle of operation being practically the same in both cleaners. The head shown in Fig. 13 is made by the Chicago Boiler

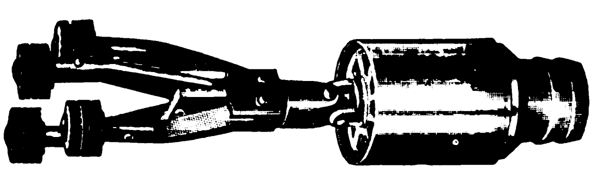


FIG. 13.—TURBINE ROTARY TUBE CLEANER.

Cleaner Company. It consists of a barrel, at one end of which are pivoted four arms carrying wheels shaped like an ordinary ratchet wheel. This head is revolved by some external source of power and the arms are thrown outward by centrifugal force, causing the cutters to chip off the scale in the tube. A jet of steam is delivered through the head and serves to clear out the cuttings as fast as the scale is removed. The Weinland tube cleaner, made by the Lagonda Manufacturing Company, Springfield, Ohio, and shown by Fig. 14, differs from the Chicago cleaner principally in the method of attaching the arms to the revolving head. The principle of operation is identical in both.

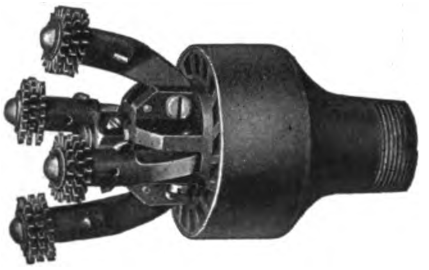


FIG. 14.—WEINLAND ROTARY TUBE CLEANER.

INTERIOR TELEPHONE SYSTEMS.

AUTOMATIC RECEIVER SWITCHES.

BY W. S. HENRY.

[In last month's article an engraver's error in Fig. 29 caused the common battery to be shown not connected to the talking wire. The corrected diagram appears herewith.]

Another method of automatically restoring the original connections by hanging the telephone receiver on its hook is illustrated by Figs. 34, 35 and 36. Fig. 34 shows the switch used in connection with a system having local transmitter batteries and a common ringing battery. Fig. 35 shows it applied to a system having common talking and signalling batteries. Fig. 36 is a view of the switch in its case; this switch is made by the Globe Telephone Manufacturing Company, Philadelphia.

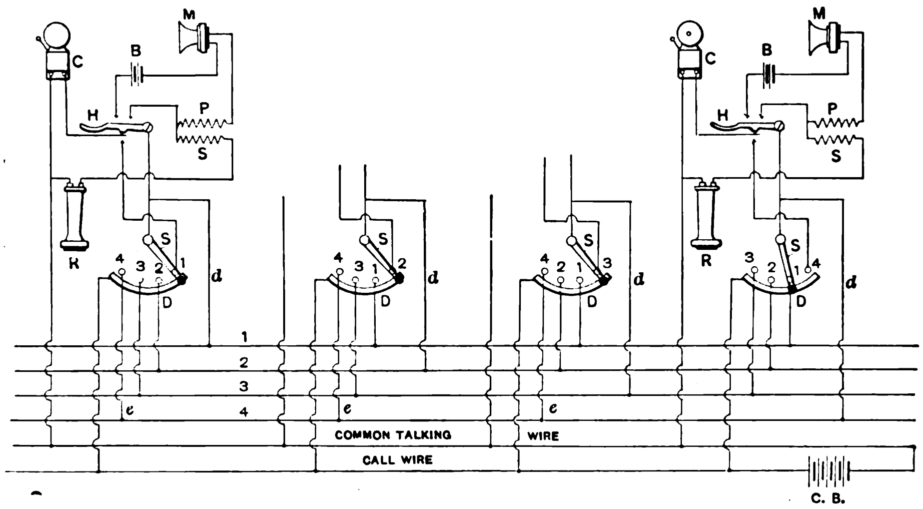


FIG. 29.—COMMON SIGNALLING BATTERY SYSTEM; INDIVIDUAL TALKING BATTERIES.

Referring to Fig. 34, the receiver, transmitter and local transmitter battery are connected in the usual manner. One centrally located battery is used for ringing or calling up the various stations. Projecting from the side toward the middle of the switch box are a number of thin, flat springs, one for each station or individual line-wire. The hook switch is fastened to a vertical plate or slide having projecting lugs on each side. When the receiver is on the hook the ends of the line springs are opposite the notches or spaces between the lugs on the vertical slide, and none of the springs can touch the slide. When the receiver is removed from the hook the slide moves up so that each lug is directly behind one line spring, as shown in Figs. 34 and 35, but still the line springs do not touch the slide.

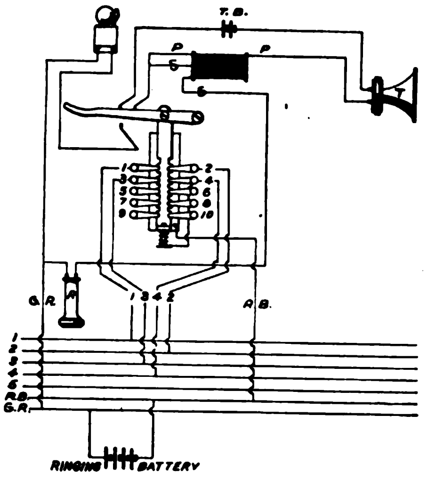


FIG. 34.—GLOBE AUTOMATIC SWITCH WITH COMMON RINGING BATTERY.

Behind the vertical slide and the line springs, but insulated from them, there is a metal plate, which we will call the battery plate because it is permanently connected to one terminal of the ringing battery through the wire, RB (see Fig. 35). In the door of the box there are two rows of holes, one hole opposite each line spring. By inserting a plug or pin (fastened by a chain to the box so it cannot be lost, but not electrically connected to any part of the circuit) through one of these holes in the door the line spring directly behind the hole can be pushed past the lug on the vertical slide and against the battery plate. By releasing the pressure on the pin the line spring comes in contact with the rear side of the lug on the vertical slide. The vertical slide is permanently connected to the hook switch and also to the line spring bearing the home station number.

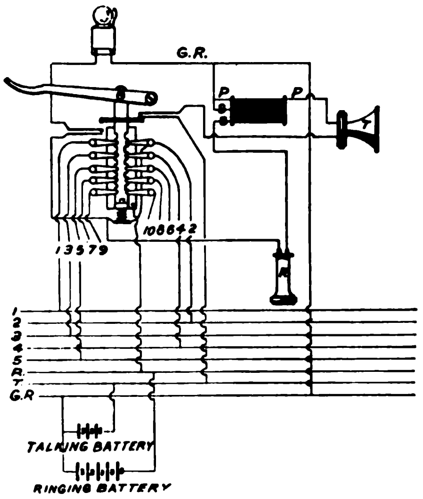


FIG. 35.—GLOBE SWITCH WITH COMMON RINGING AND TALKING BATTERIES.

To make a call the receiver is first removed from the hook and the pin is then inserted in the hole in the front of the box at the number of the station wanted. When the pin is pressed sufficiently the line spring will come in contact with the battery plate and cause a current to flow from one terminal of the battery through the wire, RB, to the battery plate. Then, if line spring No. 3 is the one pressed into contact with the battery plate, the current will pass through that spring, line 3, line spring 3 at station No. 3, through the permanent connection from line spring to the vertical slide, hook switch, lower contact of the hook switch and the bell at station No. 3; then through wire, GR, and back to the other terminal of the ringing battery. Thus only the bell at station No.

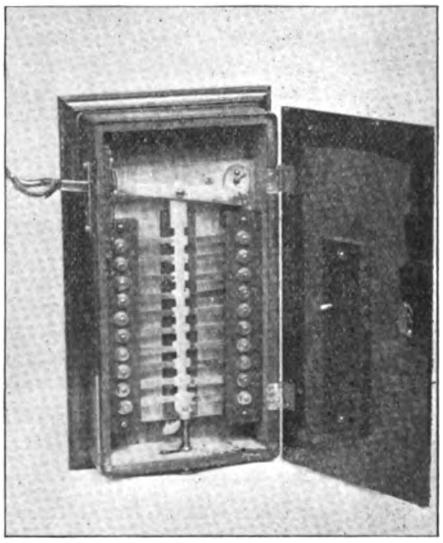


FIG. 36.—AUTOMATIC SWITCH BOX.

3 is rung. When the pin is released the line spring, 3, will press against the rear side of the corresponding lug on the vertical slide and the circuits will be properly connected for talking when the receiver at station No. 3, which was called, is removed from the hook.

A special feature of this intercommunicating switch is that a number of telephone stations may be called up and a conversation held between them all at one time. This is done by inserting the pin in turn in one hole after another at the numbers of all the stations desired. This will ring the bells at the stations desired in succession and leave all the corresponding line springs at the calling station in contact with the vertical slide. The stations, when the receivers are removed, will all be in parallel. When the conversation is finished the receivers are hung up and the vertical slide moves down to its normal position, the line springs are released from contact with it and return to their normal position directly over the spaces between the lugs on the vertical slide. Thus the switch is perfectly automatic in its action. Two more line wires are required throughout than there are stations connected to the system. The switches are usually made for 10, 16 and 20 lines.

In Fig. 35 is shown the same switch applied to an intercommunicating system with a common talking and a common ringing battery, both located at some one convenient place. Three more line wires are here required than there are stations. The vertical slide has an extra fiber cross piece near the top that closes the bell circuit and leaves the transmitter circuit open when the receiver is on the hook, and closes the transmitter circuit and leaves the bell circuit open when the receiver is off the hook. Otherwise, the switch is like the one in the preceding system; call and connections being made in exactly the same manner.

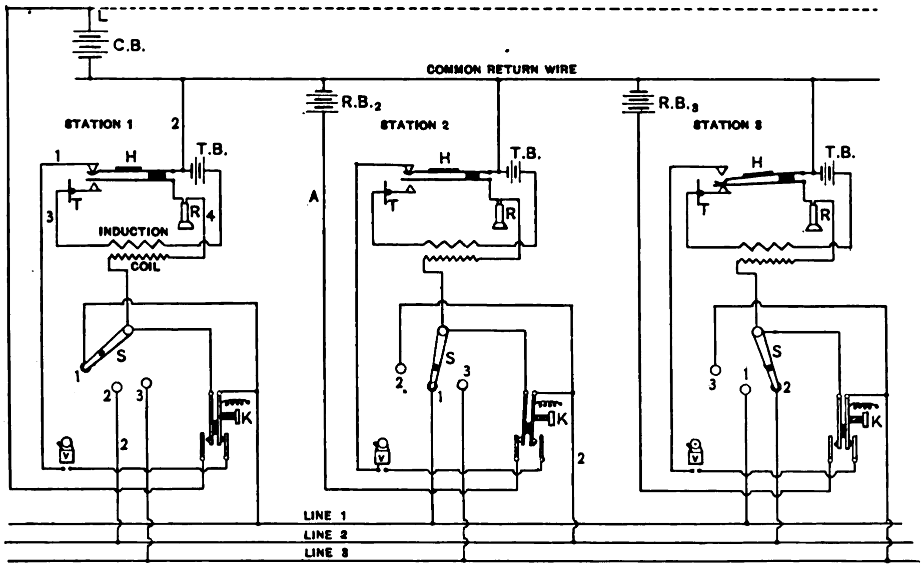


FIG. 37.—ERICSSON SYSTEM, FOR EITHER COMMON OR INDEPENDENT RINGING BATTERIES.

This switch can also be adapted for a magneto-call system and for a common ringing-battery system employing a complete metallic circuit, that is, two separate wires for each telephone. In the former system one more line wire is required than there are stations and in the latter two more line wires in addition to two wires for each station. The object of the two wires for each station is doubtless intended to avoid cross talk. In an intercommunicating system like this that does not employ a common talking battery, but has a transmitter battery at each station, the cross talk is not apt to be troublesome unless the circuits are unusually long and the line wires are run near together as in a cable. By twisting the line wires in this system in pairs, as is usually done in all regular telephone cables used in connection with complete metallic exchange systems, all cross talk can be entirely eliminated.

There is another very convenient intercommunicating telephone system that warrants a brief description. A diagram of connections of this system, which is put on the market by the Ericsson Telephone Company, New York, is shown by Fig. 37. The system illustrated here employs a battery and a vibrating bell or buzzer for signaling purposes. One common signaling battery, CB, or a separate signaling battery, RB, at each station may be used. In case only one is employed, a wire would be extended from the point, L, through all the stations, as indicated by the dotted line, and the wires, A, A, A, etc., would be tapped onto this dotted line instead of passing through a separate ringing battery, RB, at each station.

In connection with this system the Ericsson hand microtelephone, as illustrated by Fig. 38, is generally used. This instrument is complete in itself and comprises a coal-grain microphone transmitter, T, a double-pole watch-case receiver, R, and a suitable switch, H, all mounted in one handle as shown. The switch inside the handle is operated by simply closing the hand or fingers upon the hard-rubber strip, H. The wires in Fig. 38, running from the hand microtelephone at the bottom, are numbered the same as the corresponding wires at station No. 1, Fig. 37. These four wires pass through a flexible cord to a box containing the selective switch, S, the calling key, K, and the vibrating bell or buzzer, V. The ringing key, K, is of somewhat unusual construction, consisting of two springs mechanically connected by a piece of insulating material and arranged to be deflected by the thumb piece shown near near the letter K in the sketch. In the normal position one of these springs connects the individual line with the home bell. When the button is pressed this connection is broken and the selective switch, S, is connected by the other spring to the home battery line, A, as shown at Station 2.

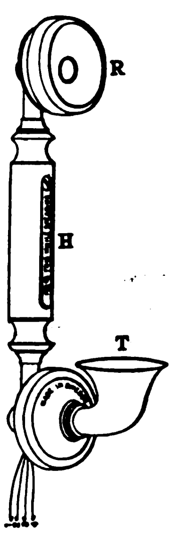


FIG. 38.

The connections shown here are practically the same as those previously shown in Fig. 21, in the September article of this series. Any station in such a system can be called up, no matter on what button its switch, S, may be left. However, a conversation cannot be held until the switch at the called station is returned to the home button, if it happens to have been left by a previous user of the telephone on some other button. This has the merit of tending to cultivate the habit of returning the switch to the home button, and still does not prevent a call from being received on the bell. (This has been more fully discussed in connection with Fig. 21.) When station No. 2, for instance, desires to call station No. 1, the switch, S_2, is turned to button 1 and the key, K, is pushed, as shown in the diagram. This completes a circuit from the battery, RB_2, through the bell at station No. 1. When the microtelephones at stations 1 and 2 are held in the hands, each piece, H, is depressed, causing the springs to come together and also to touch the transmitter contact, as shown at station No. 3, leaving the two bells on open circuit, closing the local transmitter circuits, and connecting the receivers in the main circuit. While conversing, the switch, H, must be held closed.

The hand microtelephone is quite light in weight and very convenient, especially for desk use, because it can be placed in any position on the desk, or in a pigeon hole, or hung up on an ordinary hook at the side where two persons can easily reach it.

◆

Military Experiments in Wireless Telegraphy.—The war department of the French government has decided to expend $80,000 in a series of experiments with wireless telegraphy, which are to be made secretly.

Lessons in Practical Electricity

TESTING FOR TRANSFORMER LOSSES.

The amount of power consumed by the core losses in a transformer may be determined with sufficient accuracy by connecting the secondary terminals of the transformer to a circuit of the same voltage as that of the transformer secondary and of the frequency for which the transformer was designed, leaving the primary terminals free and including a wattmeter in the secondary circuit, as shown by Fig. 35. The wattmeter will then indicate approximately the power consumed by core losses. The object in connecting the transformer up at the secondary end instead of at the primary is to enable one to use an ordinary wattmeter without interposing a transformer between the wattmeter and the circuit. The test could be just as well made on the primary of the transformer if the wattmeter could be attached direct to the primary circuit. While this test is sufficient for all practical purposes, it is not absolutely accurate, because there is a trifling copper loss during the test due to the passage of the small exciting current through the secondary winding. This is practically negligible, however, and a test made in this manner answers all ordinary requirements.

The foregoing test, as stated, shows practically the amount of power required to supply the core losses in the transformer, which comprise the loss due to hysteresis and that due to eddy currents. It is not practicable by any convenient method to separate these two losses; moreover, the separation of these two losses is not of any practical importance to the user of the transformer. Should it be desirable for purely experimental purposes to ascertain which of the two losses preponderates this can be done by connecting a voltmeter across the secondary terminals of the transformer, inserting an adjustable resistance in the circuit beyond the wattmeter, and adjusting this resistance until the e.m.f. at the secondary terminals is one-half of the normal value. If all of the core losses were due to hysteresis the wattmeter would indicate practically one-third of the loss that it indicated when the voltage was normal. If all of the core loss were due to eddy currents the wattmeter would indicate only one-fourth of the power indicated when the voltage was normal. If its actual indication, therefore, is nearer one-fourth than one-third of the power indicated with the voltage normal, the eddy-current loss preponderates; and if it is nearer one-third than one-fourth, the loss due to hysteresis is greater than that due to eddy currents.

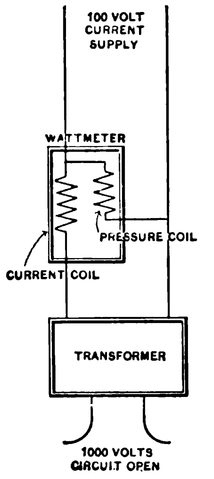


FIG. 35.—CORE-LOSS TEST.

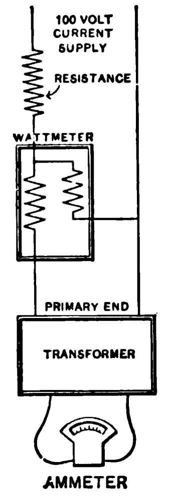


FIG. 36.—COPPER-LOSS TEST.

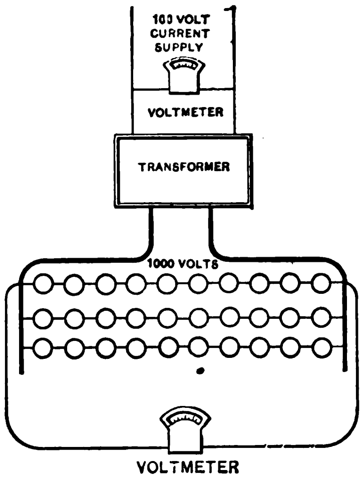


FIG. 37.—TESTING FOR FULL-LOAD DROP IN VOLTAGE.

In order to test for copper losses the most accurate method is to connect the primary winding of the transformer in series with an ammeter and an adjustable resistance across a direct-current circuit and vary the resistance until the current passed is equal to the full-load primary current of the transformer; then measure the difference of potential at the terminals of the primary winding and multiply this by the current flowing; the result is the copper loss in the primary. Make a similar test of the secondary and add the two results together to obtain the total full-load copper loss.

Another method, which is more convenient but not quite so accurate, consists in short-circuiting the secondary of the transformer through an ammeter, connecting the primary in series with an adjustable resistance across a low-voltage alternating-current circuit of the proper frequency and also connecting a wattmeter in the primary circuit, as indicated by Fig. 36; the resistance is varied until the normal full-load secondary current is indicated by the ammeter, when the wattmeter will indicate approximately the power absorbed by the windings of the transformer. As intimated above, the result of this test will not be absolutely accurate, for the reason that some of the energy supplied by the test circuit is absorbed by iron losses, which, however, are extremely small on account of the low voltage at the terminals of the primary winding.

Reference to formulas (6) and (8) (August and September Lessons) will show that the eddy-current loss varies as the square of the density; that the hysteresis loss varies as the 1.6 power of the density; as the density is practically proportional to the impressed e.m.f., the eddy-current and hysteresis losses may be considered to vary respectively as the square and the 1.6 power of the e.m.f. It is evident, then, that at the low e.m.f. necessary to load a transformer short-circuited as shown in Fig. 36, the core loss will be almost negligible. However, should one desire to refine the test a more accurate result may be obtained as follows: Make an initial test as just described and call the result the gross loss; then disconnect the secondary terminals from the ammeter, adjust the e.m.f. at the primary terminals to be exactly the same that it was during the first test; test the core losses as described in the beginning of this lesson; subtract this result from the first one, and what remains will be the actual full-load loss in the windings.

To test a transformer for drop in secondary pressure it is only necessary to connect the secondary to a supply circuit of the proper voltage, and measure the e.m.f. at the primary terminals with the primary circuit open. Then load the primary circuit with lamps, as shown in Fig. 37, and adjust the voltage at the terminals of the secondary until it is exactly the same as before, and again measure the e.m.f. at the primary terminals. The difference between the two readings of the primary voltmeter divided by the ratio of transformation will give the drop which the transformer will show at the secondary terminals when used in the ordinary manner and supplied with constant e.m.f. at the primary terminals. The object in making this test in the manner described instead of supplying the transformer from a primary circuit and loading the secondary is to avoid as far as possible manipulating the primary circuit. The test as described only requires one to close a switch in order to throw the lamps on the primary terminals, whereas, if the transformer were tested in the reverse manner the e.m.f. at the primary terminals would have to be adjusted by means of a rheostat, which might cause accidental contact with the primary circuit and result seriously.

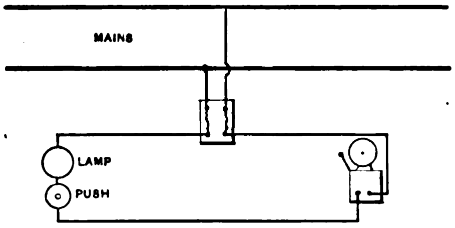
The method of testing transformer losses with which most station men are familiar consists of simply connecting the transformer up to a primary circuit and measuring the current which passes in the primary when the secondary is open. Such a test is entirely worthless in arriving at the core losses, as the current is out of phase with the primary e.m.f., and consequently, multiplying this current by the primary e.m.f. does not give the actual watts absorbed by the core losses. The simple substitution of a wattmeter, as indicated in Fig. 35, in place of a voltmeter and ammeter changes this test from one which means nothing into one which is sufficiently accurate for all practical purposes in central station work.

Letters on Practical Subjects

Electric Bells on 110-Volt Circuits.

To the Editor, American Electrician;

Sir:—In this department of the November issue you published a method of operating electric bells on 110-volt circuits. A plan much simpler and one which seems to be just as satisfactory is to connect the bell and push button up in series with a single lamp, across the 110-volt mains, as shown by the accompanying sketch.

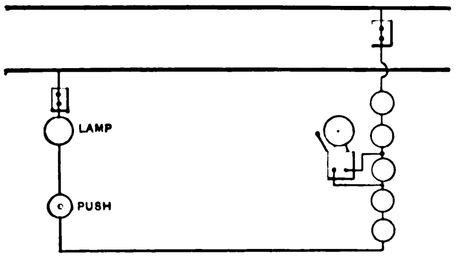


Of course, more current passes through the bell magnet than is necessary, but any ordinary bell may be adjusted for it. This plan has the advantage that no current is flowing except when the bell is ringing, and also that the lamp will serve as an indicator to show whether or not the bell circuit is all right. I have put this method into practical use with entire satisfaction to all parties concerned.

Oberlin, Ohio. Huber H. Root.

To the Editor, American Electrician;

Sir:—The methods of operating electric bells from incandescent lighting circuits which was described by Mr. Avery in your November issue is open to one objection, namely, that the lamps are always in circuit whether the bell is in use or not. It seems to me that the arrangement shown by the accompanying diagram would be better for several reasons; first, the lamps are only in circuit when the bell is ringing; second, one of the lamps can be located near the push button and serve as an indicator to show that the circuit is intact; and, third, only one wire is required between the push button and the bell, assuming that the lighting circuit runs near both the push button and the bell. The bell could be connected up in series with the lamps, of course, but this would involve breaking the high-tension circuit at the vibrator of the bell and the vibrator contacts would undoubtedly burn out after short service.

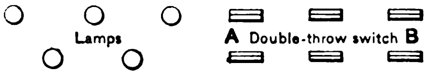


San Francisco. Arthur Bartnels.

A Wiring Puzzle.

To the Editor, American Electrician;

Sir:—The accompanying sketch represents five 220-volt 16-c.p. lamps mounted on a board with a two-pole double-throw switch. When the switch is thrown to the position marked A, all the lamps burn at full candle-power; any one may be turned off at the socket; any one or more or any combination of two or more will remain burning. When the switch is thrown over to the position marked B, all the lights are extinguished except the center one in the top row, which burns at about half candle-power. If the two lower lamps are turned off the three upper ones will light up, the middle one burning at twice the candle-power of the other two. Upon turning off one at a time, all of the lamps except the upper middle one, taking first the upper left-hand one, then the upper right-hand one, then the lower left and the lower right in succession, the upper middle lamp becomes gradually dimmer and dimmer, and when the last of the others is turned out, it also is extinguished. This lamp (the middle one in the upper row) will not burn alone, nor will any of the others burn when this one is turned off. What are the connections and what is the voltage of the supply circuits?



A. L. Havens.

Chicago, Ill.

Regulation of Standard Arc Dynamos.

To the Editor, American Electrician;

Sir:—The arc dynamos formerly built by the Standard Electric Company, as most of the older central-station men know, were provided with regulators which shifted the brushes around the commutator in order to keep the current constant. A difficulty which users of these machines have doubtless encountered is a tendency to spark badly on certain loads. In many cases this has resulted in cutting out the regulator entirely and adjusting the brushes by hand to suit the load. Even with this added attendance and care it was found that the machines when running with the brushes adjusted to give the proper current, sparked so badly as to endanger the commutator, while if the brushes were set at the sparkless position the current exceeded the proper amount. A remedy which the writer applied in the case of a 30-light 10-ampere Standard dynamo was to put a shunt around the field coils of the machine. This consisted of a small bank of incandescent lamps, the number of which could be varied. A peculiar feature of this dynamo is that the armature reaction is such as to require more current to be shunted around the field with a heavy load than with a light load, or just the opposite of what might ordinarily be expected. With a shunt of the proper resistance around the field coils the current was maintained at the proper value and at the same time the brushes ran almost sparklessly.

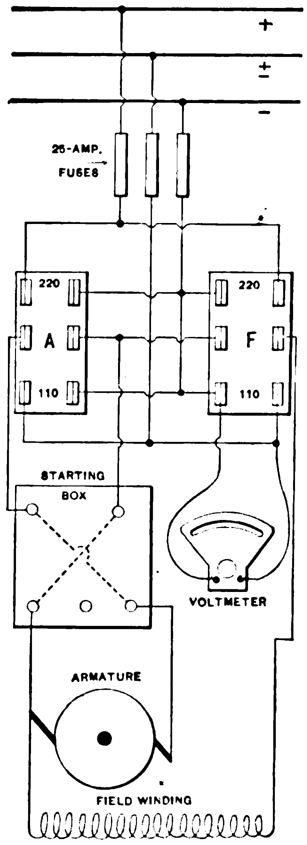
J. R. Cravath.

Chicago, Ill.

An Unusual Accident.

To the Editor, American Electrician;

Sir:—Several days ago I was running a 5-h.p. 220-volt motor from Edison mains with 25-ampere fuses at the motor switch and 50-ampere fuses at the main cut-out. The connections of the motor were as shown by the accompanying sketch, so that either the armature or the field could be connected either to the 110-volt service or to the 220-volt service, independently of each other. The motor had been running connected straight across to the 220-volt service and developing about 2 horse-power; I pulled the armature switch to shut down, and just as I was about to pull the field switch there was a sudden flash which blew all the fuses, both the 25-ampere and 50-ampere, burned off the lead to the motor field winding, and burned the voltmeter coils completely out. It seems that there must have been an abnormal pressure on the circuit just at that moment, but I don't see how the Edison service could have got crossed with a high-tension circuit, as the wires here are all underground. I would be glad if some one would suggest the cause of the occurrence.



A. W. Shaw.

Boston, Mass.

A Remedy for Irregular Voltage.

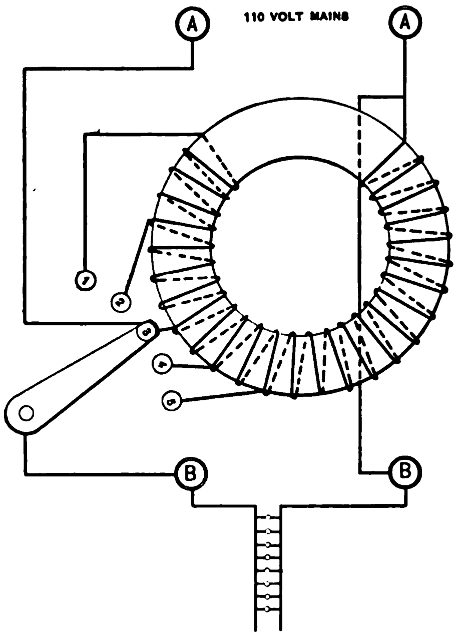
To the Editor, American Electrician;

Sir:—It often happens in small central stations that the voltage at the consumers' lamps is very different at different points of the distributing mains; consumers near the station will have a voltage higher than the rated voltage of their lamps, and consumers remote from the station will suffer from low voltage. In alternating-current plants this irregularity can be easily remedied by installing a simple auto-transformer at the entrance of the low-pressure mains, connected up as shown by the accompanying sketch.

With the switch on button 3, as shown in the sketch, the e.m.f. of the mains will be applied to the terminals of the lamps; moving the switch lever to button 2 or 1 will increase the pressure at the lamps, and moving it to 4 or 5 will decrease the pressure. The one form of apparatus, therefore, is suitable either for places where the voltage is too high or places where it is too low.

The auto-transformer can be easily made by any central-station man. The core can be made up of sheet-iron rings, such as are used for armatures, and the winding can be calculated by means of the formulas recently given in your lessons department. It is not necessary, of course, to use the exact number of contact buttons shown in the sketch; a wider range of regulation can be obtained by increasing the number of taps. It is only necessary that that portion of the winding between the connections to the secondary of the transformer be calculated for the secondary e.m.f. Thomas Barnard.

Toronto, Ont.



Electrical Catechism

548. Are there any methods for obtaining electricity from heat, other than the thermopile and the engine and dynamo?

There is a number of methods in which electricity may be obtained from heat energy. One general class depends upon the maintenance of a constant difference of temperature between different parts of the circuit. Another general class depends upon a changing temperature of the same part. The latter class includes two quite distinct methods which may be called "pyro-electric" and "pyro-magnetic."

549. What are pyro-electric generators?

Theophrastus (about 450 B.C.) describes what he called an "electric stone" that had the power of attracting light substances when heated. Aside from atmospheric electricity, this seems to have been about the first knowledge of what we now know as static electricity. Certain stones and crystals become charged positively at one end and negatively at the other when heated, and then show the attractive and repellant effects of static electricity. The tourmaline takes its name from the Ceylonese word "tournamal," meaning "ash-collector." The electrification is due to the change of temperature. No commercial use is made of such electrification, except possibly to increase the sale of certain stones.

550. What are pyro-magnetic generators?

These are devices based upon a discovery made by Gilbert about 1600 A. D. that iron and other magnetic substances lose their magnetic properties when heated white hot. In 1868, Gore made use of this phenomenon for varying the magnetic flux through a coil and so inducing a current. This was further developed by Edison, Menges and Tesla, but none of them arrived at commercial success. The same phenomenon has been applied to the operation of small motors by Thomson and Houston, McGee, Schwedoff, Cooper, Berliner, Edison and Menges.

551. Has heat been used in connection with chemical action for developing electricity?

This has been tried by a number of people. In 1881 Kendall obtained currents from platinum plates heated to redness in hydrogen and other gases and with melted salts or glass, getting about one-half volt per cell. Following some experiments of Becquerel in 1855, Jablochkoff in 1877 and Brard in 1882, constructed what they called "electro-generative slabs" composed of carbon, nitrate of potash and copper, which produced electricity by their own combustion when thrown into a fire. In 1886, Case announced a kind of cell based upon the fact that chronic chloride dissolves metallic tin when heated to the boiling point and precipitates it when cooled; this cell developed an electromotive force of 0.26 volt. In 1883 Acheson developed 2.25 volts by heating manganese binoxide between two concentric cylinders. In 1887 Ettinghausen and Nernst obtained an e.m.f. of 0.00125 volt by sending heat through a conductor in a strong magnetic field, apparently converting some of the heat into electricity. In 1886 to 1889 Acheson worked along this line and devised a number of plans for changing electricity into heat in the influence of a magnetic field. In 1896 Jacques brought out a cell in which current was obtained by heating iron and carbon electrodes with caustic soda.

552. Is the heating effect of the electric current of much practical importance?

The heating effect must be taken into account in the design, construction and operation of almost all electrical apparatus, to prevent excessive rise of temperature. On the other hand, the heating effect is desired for many purposes, and it is the basis of many useful applications of electricity.

553. What governs the amount of heat from a current?

It varies both with the current and with the resistance. No substance is known that has perfect conductivity; that is, every conductor has more or less resistance (see Nos. 312 to 329). The passage of current through resistance causes a certain fall of potential or voltage, which by Ohm's law equals the product of current by resistance. The product of current by this drop represents the energy lost or changed from electricity into heat, and may be expressed in an equation:

$$W = I \times E = I \times I \times R = I^2R.$$

The product of current by drop, or of current squared by resistance, when multiplied by the time during which the current passes, represents the amount of heat developed. The unit of heat may be taken as the joule, which equals the heat developed by one watt acting for one second; or it may be taken as the calorie, which equals the amount of heat necessary to raise the temperature of one gram of water one degree Centigrade, and equals 4.2 joules or 4.2 volt-ampere-seconds, or 4.2 watt-seconds. (See Nos. 218, 220 and 221.) This may be expressed in an equation:

$$\text{Calories} = \frac{\text{watts} \times \text{seconds}}{4.2} = 0.238 \times \text{watts} \times \text{seconds}$$
$$= 0.238 \times \text{current} \times \text{drop} \times \text{time}$$
$$= 0.238 \times \text{current} \times \text{current} \times \text{resistance} \times \text{time}$$
$$= 0.238 \times I \times E \times T$$
$$= 0.238 \times I \times I \times R \times T = 0.238\ I^2RT.$$

554. What are some of the ways in which the heating effect may be avoided or made small?

Conductors for carrying current must be sufficiently large or there will be not only an excessive loss on the line, but the temperature of the conductors will be liable to rise so high as to endanger the insulation or even set fire to surrounding substances. For this reason the insurance and electrical interests companies have made a careful study of the conditions under which electricity may cause fire risks and have adopted sets of rules governing both the size of wire that must be used for certain currents and also the manner of placing and insulating the conductors. A strict compliance with the "National Electrical Code" is generally insisted upon for safe installation and operation.

Queries and Answers

IMPORTANT.—No attention will be given to inquiries which do not give the full name and address of the inquirer.

What size and how much iron or steel wire must I use for a rheostat in series with a 10-ampere stereopticon arc lamp to work on a 110-volt circuit? H. L. I.

Use 760 ft. of No. 12 galvanized steel wire, Birmingham wire gauge.

What size core and coils should I use for an X-ray coil to give a 5-in. spark? E. F. W.

Make the core 1½ ins. in diameter and 18 ins. long. Use two layers of No. 12 wire for the primary coil and 7 lbs. of No. 38 double silk-covered wire for the secondary coil.

Please give me the sizes of copper wire to use for fuses from 25 to 100 amperes. H. H. P.

25 amperes	No. 25
30 amperes	No. 24
35 amperes	No. 23
40 amperes	No. 22
50 amperes	No. 21
60 amperes	No. 20
70 amperes	No. 19
85 amperes	No. 18
100 amperes	No. 17

Can I increase the capacity of a 12-pole single-phase alternator by running it at a higher speed and reducing the exciter speed? (2). The machine originally ran at 1300 r.p.m., but this has been reduced to 900 r.p.m.; what would be a good speed at which to run it? C. P. G.

No. (2) 1000 r.p.m. would be a good speed as this gives 60 cycles, which is a standard frequency.

A storage battery of 44 cells requires 20 amperes for 3½ hours to charge it. How many amperes would be required to charge 11 cells of the same battery in the same time? N. A. D.

It will take the same amount of current to charge 11 cells as to charge 44 if the cells are in series in both cases. The difference will be in the e.m.f. applied to the terminals in the group and not in the current flow.

Why must the lamp socket on a photometer rotate? H. L. F.

Because the standard candle-power is the average given out horizontally, and in order to obtain the average effect the filament must be rotated. A measurement taken with the filament stationary would show the candle-power given in one particular plane but not the average strength of light all around the lamp.

Would not an alternating current of proper frequency be as good for an induction coil as a direct current with a vibrator? (2). Would a condenser be necessary? F. E. G.

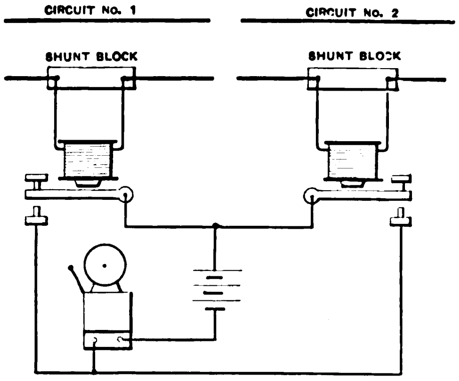
No, an induction coil requires its exciting current to be varied as nearly instantaneously as possible, and a vibrator more nearly approximates this than the gradual variation of an alternating current. (2) A condenser is always advisable but it would not make the use of alternating current satisfactory.

I have an induction-motor frame which I wish to wind as a single-phase motor. The bore of the stator is 7¾ ins., it has 24 slots ⅝ in. deep and ⅝ in. wide, and the axial length is 3⅝ ins. What winding should I use on the stator for 100 volts and 60 cycles, and what will the speed be? G. W. T.

Wind it with four coils, using No. 13 double cotton-covered wire and putting 60 turns in each of the four coils. Divide each coil into two sections of 30 turns each and leave two slots vacant in the center of each coil. This will give 20 active slots, each slot containing 30 wires. The speed will be approximately 1700 r.p.m. The motor will not be self-starting.

Is there any way to connect an electric bell so that it will ring when any one of four circuits opens? (2). How much power is required at the pulley of a 30-kw. direct-current generator? B. R.

The diagram herewith shows one method of connecting up an alarm; only two circuits are shown, but the plan can be extended to any number. (2) This depends upon the efficiency of the generator. A 30-kw. machine of average efficiency will require about 35 horse-power at the pulley.



Which is the best for long-distance transmission of light and power, two-phase or three-phase alternating current? (2). Can lights and railway service be supplied by a single generator with good results on the lighting circuit? W. B. L.

A three-phase circuit is more economical for transmission, but two-phase distribution is easier to balance; consequently, good regulation at the station is more easily obtained with two-phase than with three-phase alternating current ordinarily. (2) Yes, assuming that a rotary converter is used to supply the railway circuit. Much better results will be obtained, however, by the use of separate generators.

How can I find out whether an invention has been patented or not? (2). What is a carbureter? (3). What is an inspirator? (4). How is the size of fuse required in the main cut-out of an incandescent lighting system ascertained? G. L.

Have a reliable patent attorney make a preliminary "search" for you. (2) A piece of apparatus used in connection with gasoline and kerosene oil engines for the purpose of saturating the incoming air with the oil vapor. (3) An injector. (4) The size of fuse must be such that it will blow when the current exceeds the proper amount for the conductors immediately beyond the fuse. The Underwriters' rules specify the allowable amount of current for different sizes of wire.

Is there any objection to the use of a three-wire line for transmitting power by single-phase high-tension alternating current when the two sides of the system can be kept practically balanced? (2). Is there any better arrangement than to run the two alternators in parallel and use two station transformers with the primaries in parallel and the secondaries in series on the three-wire line? S. R. I.

No, but the middle wire is unnecessary. You can obtain the same economy of transmission by omitting the middle wire and using suitable transformers at the two ends of the transmission line. (2) No, unless your machinery is so arranged that you could couple the alternator shafts rigidly and connect the alternators in series across the line; this will eliminate the station transformers.

Is there any formula for connecting the coils of a two-path armature to the commutator? By "two-path" I mean a wave-wound armature having two parallel circuits through it and running in a multipolar field. N. F. C.

If the winding is as nearly symmetrical as possible, that is to say, the number of coils is either one less or one more than a multiple of the number of magnet poles, the following formula will apply:

$$\frac{\text{Segments} - 3}{\text{Pairs of poles}} = \text{number of segments between the two to which the terminals of any one coil are connected.}$$

For example, if a four-pole machine be provided with a two-path armature of 51 coils, there will be 51 commutator segments, and the two segments to which the terminals of any one coil must be connected will have

$$\frac{51 - 3}{2} = 24 \text{ segments between them,}$$

counting the shortest way around the commutator.

Give me a rule for finding the approximate horse-power of an engine. (2). What is a rotary engine? (3). In a triple-expansion engine is steam from the boiler used in each cylinder, or does the first cylinder exhaust in the second and the second into the third? G. L.

The formula for horse-power is.

$$\frac{P\,A\,N\,S}{33{,}000} = \text{H.P.},$$

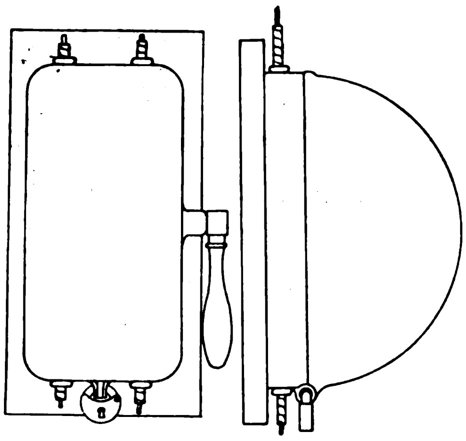
in which P is the mean-effective pressure in the cylinder; A is the area of the piston; N is the number of strokes per minute; S is the length of stroke in feet. A formula for approximating the power of a simple engine is as follows:

$$\frac{R\,I\,D^2}{700} = \text{H.P.};$$

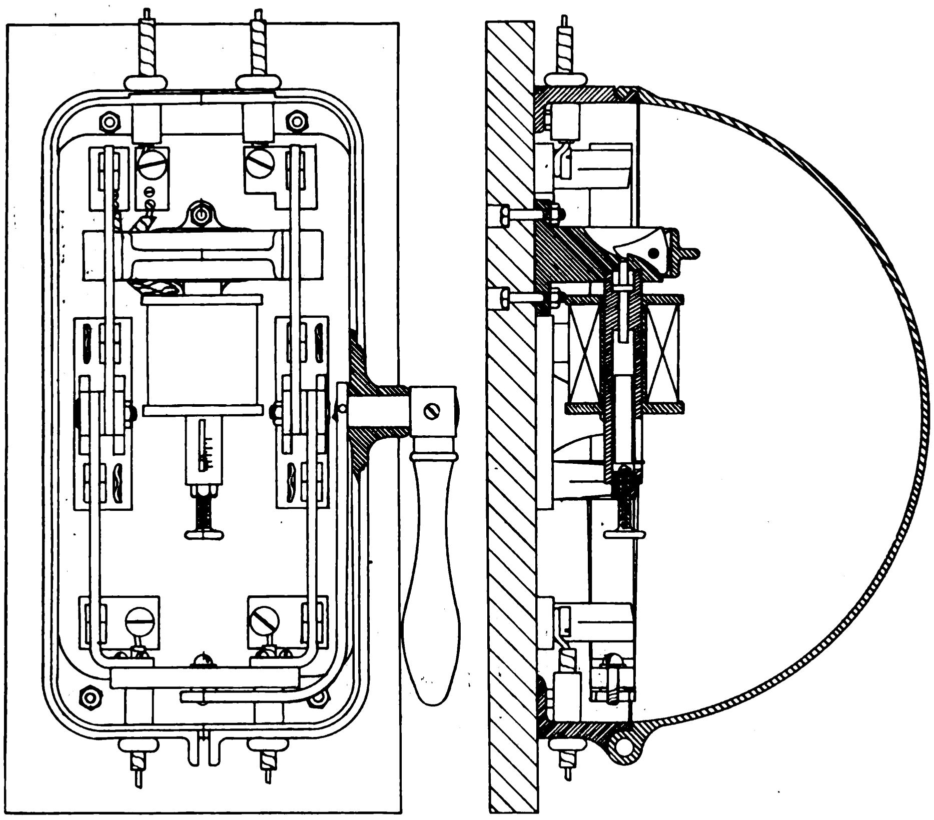
in this formula, R is the revolutions per minute; I is the length of the stroke in inches, and D is the diameter of the cylinder. (2) An engine which has no reciprocating parts. (3) The high-pressure or smallest cylinder exhausts into the intermediate, and the intermediate exhausts into the low-pressure or largest cylinder.

A FLAT-RATE CIRCUIT-BREAKER.

Many schemes have been devised for the purpose of enabling a central station to supply service at flat rates without being subjected to the disadvantage of having a consumer pay for 10 lamps and use 15. A recent device of this character operates to cut in a resistance in series with the entire house wiring when the current flow exceeds a certain amount, so that the lamps will not be cut off entirely but the brilliancy will be reduced to a dull red and remain that way until a sufficient number of lamps is turned out to allow the protective device to cut out the resistance. The objection to cutting out the lamps entirely has been that if the automatic cut-out or circuit-breaker was so arranged that the householder could not restore it, then great inconvenience would be suffered while waiting for someone to come from the central office or station and restore the circuit, whereas, if the circuit-breaker were arranged so that the householder could restore it after it had been thrown out, it would be a simple matter to fasten it in this position so that it could not open the circuit.



FIGS. 1 AND 2.—ENCLOSED CIRCUIT-BREAKER.



FIGS. 3 AND 4.—INTERIOR OF THE CONSUMER'S TYPE OF CIRCUIT-BREAKER.

Mr. B. Parks Rucker, of Philadelphia, has devised an ingenious form of circuit-breaker which can be restored by the householder but cannot be fastened in the closed position. This is illustrated by the accompanying engravings. The principle of the device is, briefly, the employment of two double-pole switches connected in series in the circuit, one of these switches being controlled by the usual circuit-breaker solenoid and trigger, and the other one being controlled by a handle which extends through the side of the closed case, as shown in Figs. 1 and 3. The handle which operates the second switch also serves to close the circuit-breaker switch, but in order to do this the hand switch must be opened first, as will be evident from an inspection of Fig. 3. The circuit-breaker switch closes upward and the hand switch closes downward. When the circuit-breaker switch is thrown by an overload its blades turn outward and downward in the usual manner until they almost reach the position of the hand switch, which is closed. Raising the handle of the hand switch restores the blades of the circuit-breaker switch to the closed-circuit position, but the hand switch being opened by this movement and its contacts being in series with those of the circuit-breaker switch, the house circuit is still open and light cannot be had until the handle is thrown down again, which leaves the circuit-breaker free to come out if the load is still excessive.

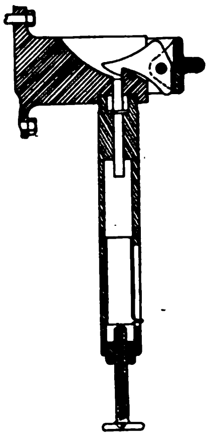


FIG. 6.—THE TRIP.

Mr. Rucker has also applied this device to switchboard instruments in order to avoid the necessity for testing the circuit for the purpose of making sure that the line is clear before restoring the circuit-breaker. Fig. 5 shows the switchboard form of instrument, which differs from the other only in having no case and in having the handle of the switch mounted on the insulating cross-bar of the blades, as in the case of ordinary switches. Another advantage of the switchboard instrument is that a switchboard attendant cannot restore a circuit-breaker and deliberately hold it in while there is an overload on the line without danger of establishing personal connection with the live contacts, as there is no handle on the circuit-breaker switch. It is evident also that the invention combines in one apparatus a circuit-breaker and a main switch, the lower part of the instrument taking the place of the ordinary main generator switch.

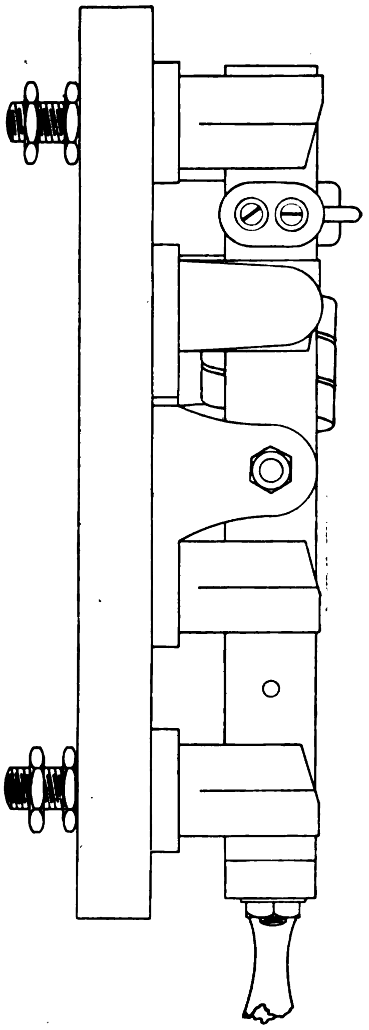
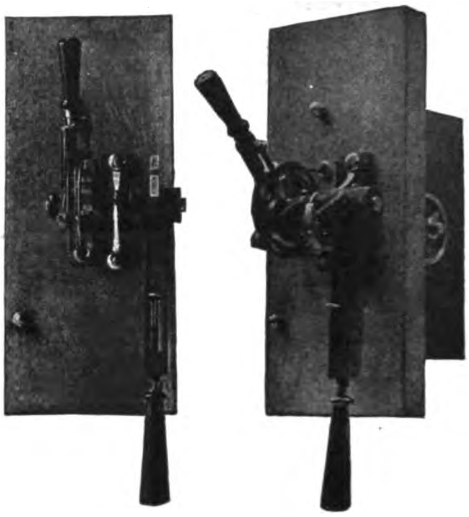


FIG. 5.—SWITCHBOARD TYPE.

A NEW TYPE OF THEATRE DIMMERS.

The conditions encountered in the installation of theater dimmers demand such a variety of types, and so many different arrangements and combinations, as to make nearly every installation a special job, requiring work different in some respects from standard. This not only increases the expense, but occasions delay and uncertainty in filling orders, besides making the work more or less experimental. These considerations have led The Wirt Electric Company, of Philadelphia, to design a type of dimmer permitting the utmost flexibility in installing, while still maintaining a standard of construction. The further advantages gained are extreme ease of operation and compactness. When demanded, the dimmer proper may be placed below the stage floor, or on a bracket high above the floor, the interlocking mechanism only being on the switchboard. By this arrangement space is economized to such an extent as to have all levers and interlocking parts on a very small panel. For example, a bank of 25 dimmers may be controlled on a board two feet square and occupying a depth of only six inches.

The advantages will be best understood by referring to the illustrations. Figs. 1, 2 and 3 give three views of a single unit, showing the dimmer on the back of the board and the interlocking mechanism, together with the master lever and a portion of the interlocking shaft on the front of the board. The loose sheave on the interlocking shaft carries a short lever and handle, and is connected to the smaller sheave on the dimmer shaft by means of a flexible cable. This enables one dimmer unit to be operated independently of the rest by its own lever. A cam permanently attached to the interlocking shaft near the loose sheave engages with the spring plug attached to the short lever when the handle is given a quarter turn. With this arrangement any desired dimmer may be picked up by the master lever in whatever position it happens to be, and



FIGS. 2 AND 3.—SINGLE UNITS.

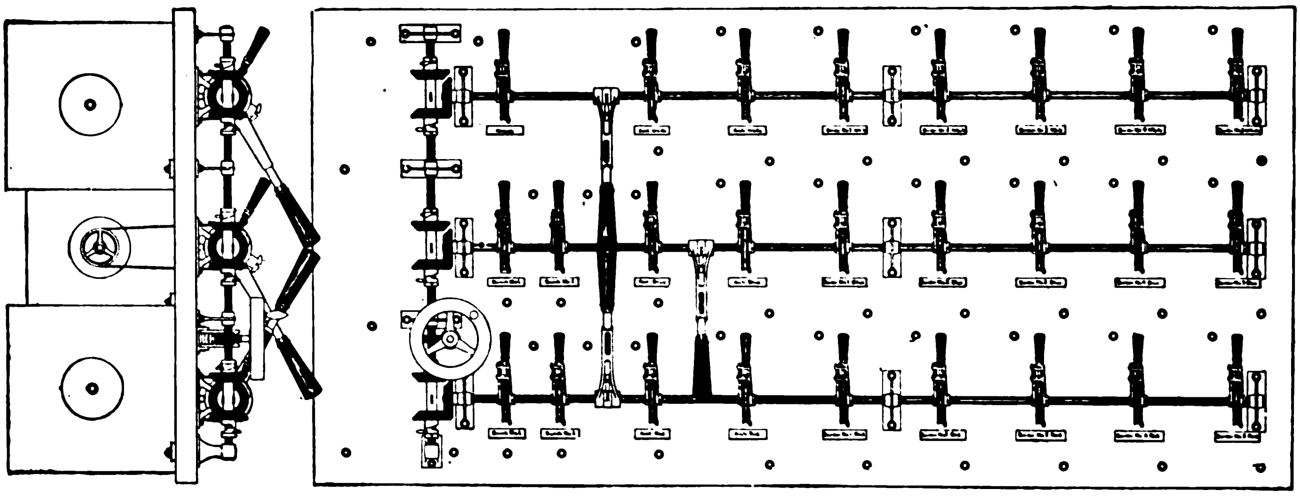


FIG. 4.—PLAN OF A LARGE DIMMER BOARD.

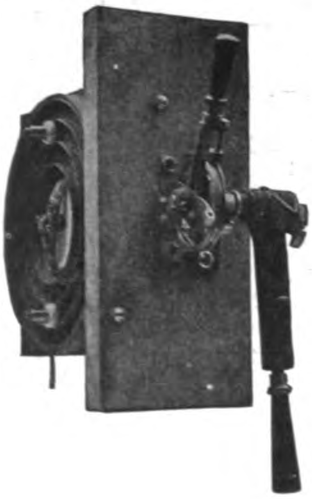


FIG. 1.—SINGLE UNIT.

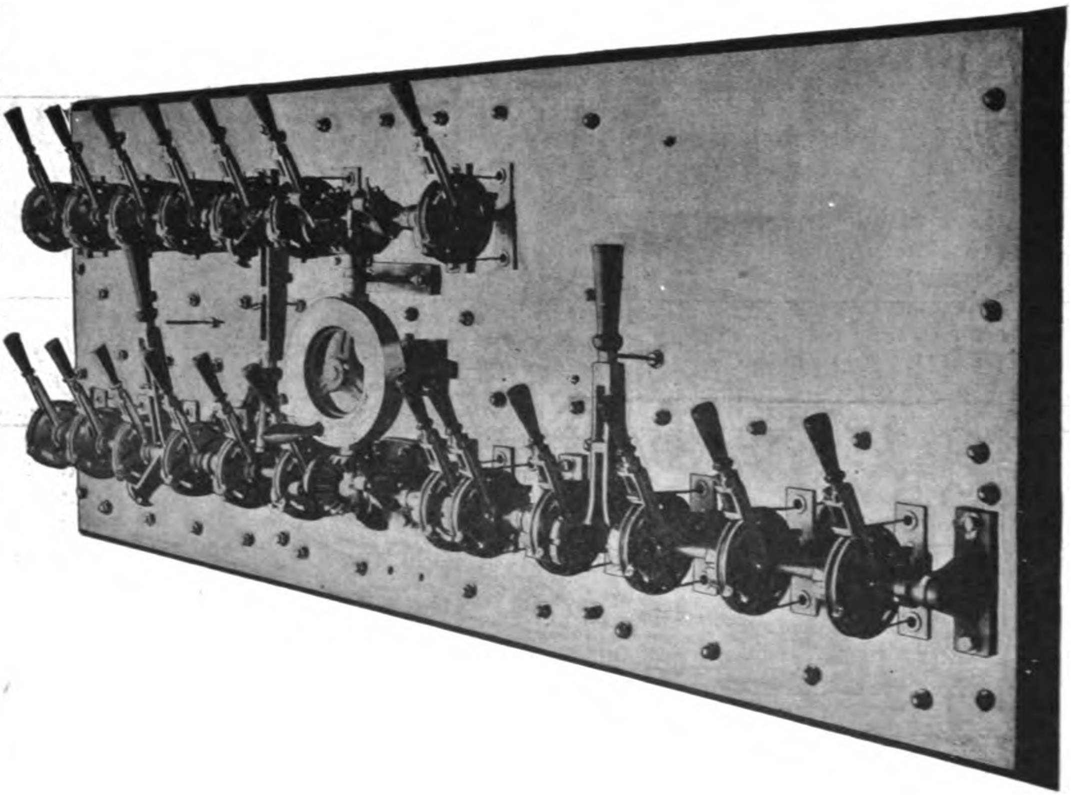


FIG. 5.—FACE VIEW OF A LARGE DIMMER BOARD.

Fig. 4 shows a plan of a dimmer board, taneously.

Fig. — shows a plan of a dimmer board, upon which are mounted 24 three-wire "universal" dimmers. The plan shown here is one best suited to the conditions usually met with. Fig. 5 represents a dimmer recently shipped to one of the large western cities. The dimmers are arranged in three banks on three interlocking shafts. The top bank for control of the white lights has dimmers for five border circuits, the proscenium arch, the footlights and the auditorium. The middle bank for control of the blue lights has dimmers for five border circuits, proscenium arch and footlights, and two circuits for bunch lights. The lower bank controlling the red lights also has dimmers for five border circuits, proscenium arch and footlights. The two dimmers for bunch lights on the middle bank are also arranged for interlocking on the lower bank. This permits the bunch lights to be operated either with or against any other lights.

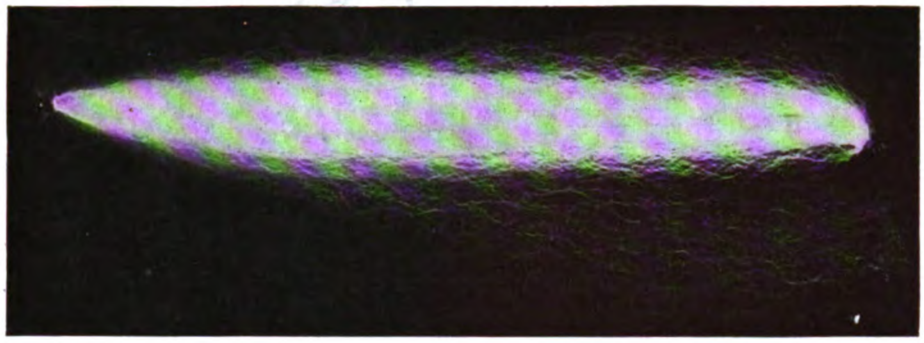


FIG. 2.—A 42-INCH "SPARK" FROM AN INDUCTION COIL.

To the left is shown a gang shaft connected by pairs of mitre gears to the three interlocking shafts. These mitre gears are so arranged as to throw either one of any pair into action, or throw it out entirely. This permits of operating any or all of the three interlocking shafts, and in any combination of directions; they may be run in the same or in opposite direction, as preferred. The gang shaft is supplied also with a worm gear for slow motion, which may be thrown out when desired. Each interlocking shaft has its own master lever, and one of these levers may operate its own shaft, or any of the others. The master levers, being provided with interlocking attachments, may be thrown flat against the board when not in use, and will pick up the interlocking shaft at any position.

This outfit, as shown in the plan, presents some peculiar advantages over other forms. In addition to being very compact it affords opportunity for securing practically any light effects, and owing to the ease with which the switches run, a single operator is able to throw the entire bank of dimmers without great effort. This ease of operation is chiefly due to the construction of the switch and commutator employed. The radius of the switch arm is about 2½ ins., and therefore with a given pressure more easily rotated than if it were longer. The switch itself is a leaf brush giving excellent contact with a minimum pressure.

The dimmers are all mounted back of the dimmer board, each unit independent of the rest. Provision is made for taking up any slack that may occur in the flexible steel cables when new, and other cables may be readily substituted should it be necessary to change the position of any dimmer.

INDUCTION COIL TO GIVE A 40-IN. SPARK.

In order to carry out some original experimental work on a larger scale than had heretofore been attempted, the Japanese Government placed an order in the early summer with Queen & Co., Philadelphia, for two induction coils each capable of giving a "spark" one meter (39.37 ins.) in length. The final test on the coils occurred a few days ago and they were found to more than fulfill the requirements, a spark of 45 ins. being readily obtainable between the secondary terminals. The construction of the coils was in many respects novel, involving considerable departure from the orthodox methods of construction. It will be seen from the illustration that the secondary is built in two entirely distinct sections. The center ends of the two sections are connected together and grounded to the primary winding. There is no hard rubber tube used for insulation between the secondary and primary. The cabinet at the right hand of the illustration contains the condenser, the switches for making the various connections, and the interruption. It was found necessary to devise a special form of mechanical interrupter, which is operated by means of a small motor inside of the cabinet. The speed of the motor is variable by means of a suitable rheostat, so that any number of interruptions per minute within reasonable limits is obtainable. Both the cabinet and the coil proper are mounted on casters and can be readily moved from place to place.

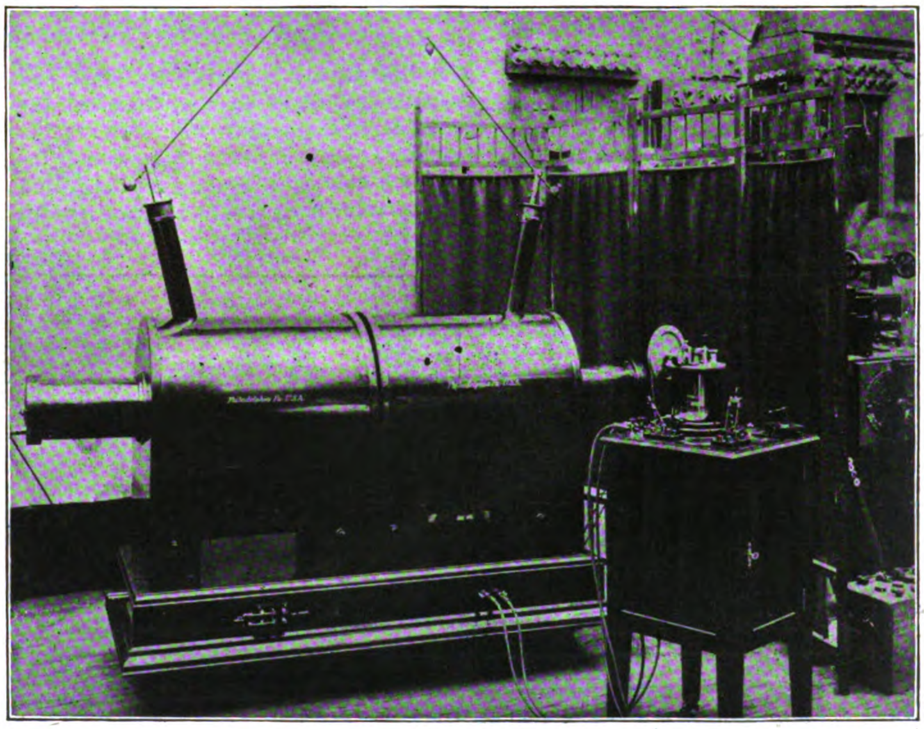


FIG. 1.—INDUCTION COIL CAPABLE OF GIVING A 45-INCH SPARK.

The induction coil proper is easily dissectible, the two halves of the secondary being held on the base by wooden pins. The windings of the coil and the capacity of the condenser were so arranged that the primary can be supplied from either a low or high-voltage circuit. In order to secure the longest spark length a potential of 40 volts at the terminals of the primary was found most suitable. At this potential a current of about 30 amperes would give a very heavy 42-in. spark with the interrupter running at approximately 3 breaks per second. One of these 42-in. sparks are shown in the accompanying illustration; with the secondary terminals close enough together to secure about a 32-in. spark, the number of breaks per second can be very greatly increased and a correspondingly smaller amount of current used in the primary. Fig. 1 shows the coil adjusted for producing a spark approximately 32 ins. in length, with the interrupter running at about 20 breaks per second.

New Apparatus and Appliances

NEW ENGLAND SLOW-SPEED MOTORS AND DYNAMOS.

The New England Motor Company, of Lowell, Mass., has lately placed on the market a new type of slow-speed direct-connected apparatus, designated "Type F," Figs. 1, 2 and 3 show one of these machines and some of its details. One of the most important features is what is termed an "equalizing" magnetic system, which is illustrated in Fig. 1. All the magnet poles of like polarity are connected magnetically by a ring, the section of which bears a definite ratio to the rest of the magnetic current, so that any inequality in the strength of the field caused by the displacement of the armature, or accident to individual field coils, is corrected. By this arrangement, it is claimed a perfectly symmetrical field is always secured. This is, of course, a most desirable result in generators and motors provided with multiple-circuit armatures, and it is advantageous even in machines having two-circuit windings. This construction is protected by patent and should not be confounded with the Dobrowsky pole-bushing, in which all poles are magnetically connected more or less completely. The use of this pole system, it is stated, permits the use of relatively high speed when desirable. Another important advantage claimed for the method of mounting the pole shoes here shown is that, owing to the fact that they are adjustable in a rotary direction, the saturation at the pole tips can be varied; that is, it is possible to over-saturate either the leading or trailing horn of a motor or generator at will without shutting down the machine. By loosening the brass bolts which clamp the pole rings together they can be adjusted circularly, just as the position of of the brush-holders is adjusted around a commutator.

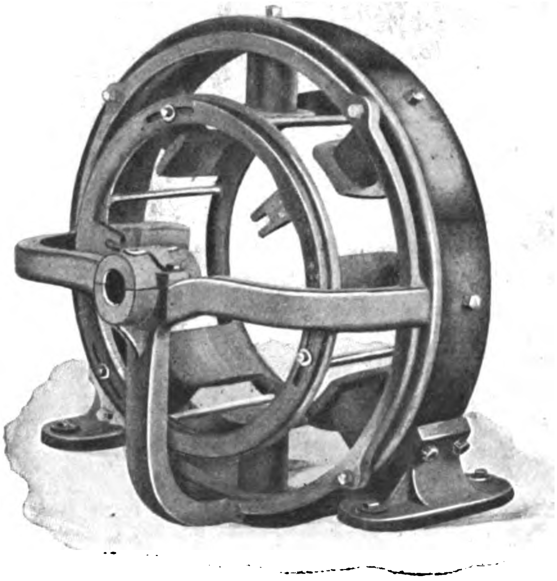


FIG 1.—MAGNET FRAME WITH POLE-EQUALIZING RINGS.

Fig. 2 gives a good idea of the general appearance of the machine as arranged for direct-connected work. A light but strong three-armed bracket carries the bearing at each end of the machine, except in cases where only the front bracket and bearing are required, the other end being supported by the shaft to which the machine is connected. Fig. 3 shows the armature complete. Machine wound, interchangeable coils, heavily insulated and then shaped, are used. The back end of the armature is protected from oil, dust and mechanical injury by a closely-fitting metal shield. The winding is well below the surface of the core, and is further protected by hard-wood strips held in place by steel wire bands.

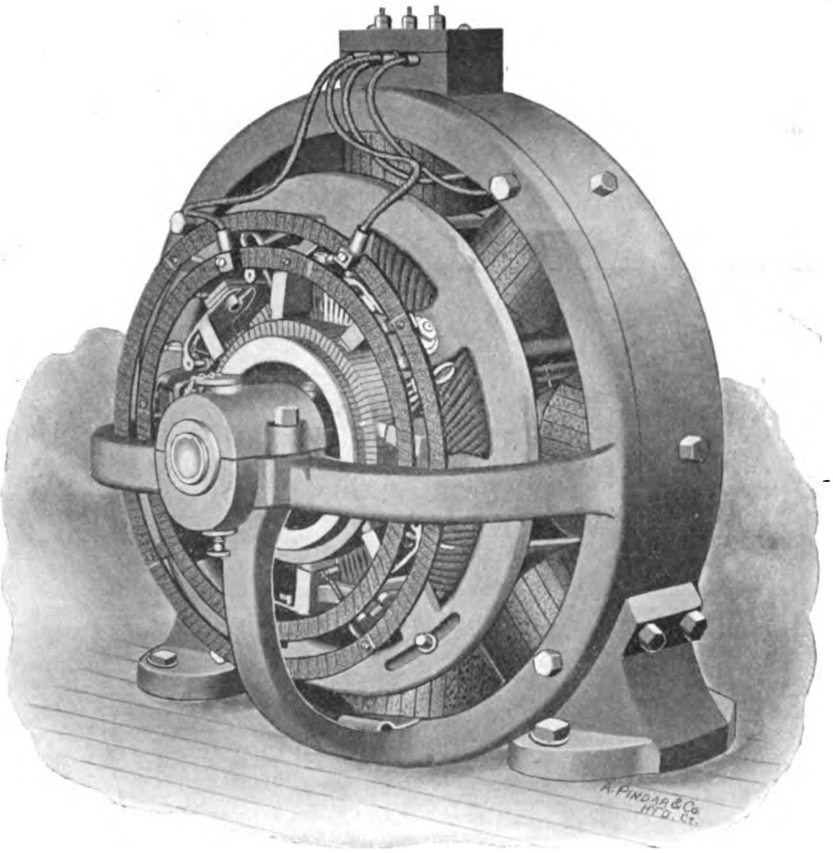


FIG. 2.—MULTIPOLAR GENERATOR WITH POLE-EQUALIZING RINGS.

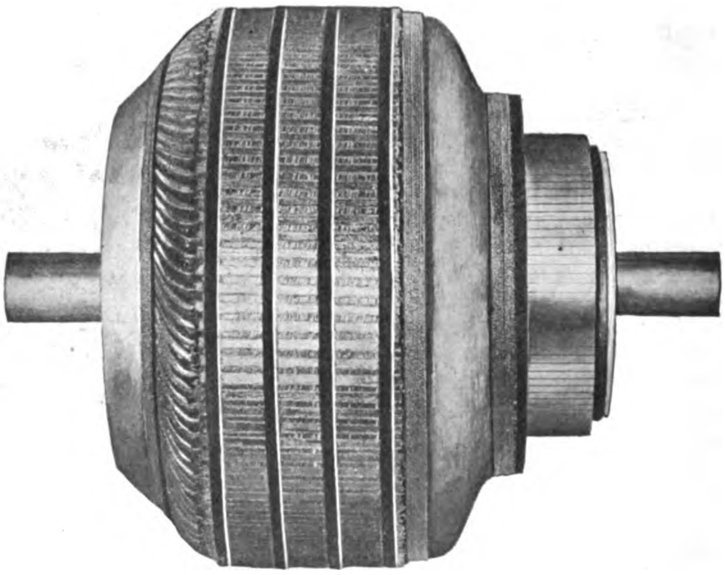


FIG. 3.—COMPLETE ARMATURE AND COMMUTATOR.

These motors and generators are manufactured in sizes from ½ to 30 horse-power, and to run at speeds ranging from 100 r.p.m. up. Motors may be arranged to hang inverted from the ceiling, on the wall or with the shaft in a vertical plane.

The method most frequently adopted for factory transmission is to have the motor suspended from the ceiling and coupled directly to the line shaft. When used for direct connection to ventilating fans, machine tools, printing presses, etc., it is usual to furnish the motor with only one bearing bracket at the commutator end, the other end of the shaft being directly coupled to the shaft to be driven. This is also the best arrangement for direct-connected generator sets.

STURTEVANT EXHAUST HEAD.

An interesting example of the practical application of centrifugal force is presented in the design of the Sturtevant exhaust head; the accompanying illustration serves to show both its construction and method of operation. Externally it is an inverted cone of heavy galvanized steel plate attached to the end of the exhaust pipe. Its interior construction consists of two branching pipes extending upward from the connected to the exhaust pipe; these individual pipes, which are parallel to the sides of the casing, terminate in elbows from which the steam escapes. Its enclosure by the circular sides of the case gives it a whirling motion, which brings centrifugal force into play. Inasmuch as this force is proportional to the weight of the substance acted upon, and as water weighs about 1600 times as much as does exhaust steam, the natural result is that the water contained in the steam is thrown outward with great force. Striking upon the sides of the cone, it trickles to the bottom and escapes through the drip pipe. Such oil as may be entrained with the steam is likewise separated. The steam, now dry, is forced downward by the additional entering volumes and quietly escapes to the atmosphere through the central pipe. The central pipe is made larger than the exhaust pipe, and as the cold sides of the case tend to condense a portion of the steam, it is manifest that no back pressure is imposed upon the engine. The absence of baffle plates and the simplicity of design are the best guarantees of endurance on the part of this head. The head is built by the B. F. Sturtevant Company, Boston, Mass., in sizes to fit exhaust pipes of from 1 in. up to 36 ins. diameter.

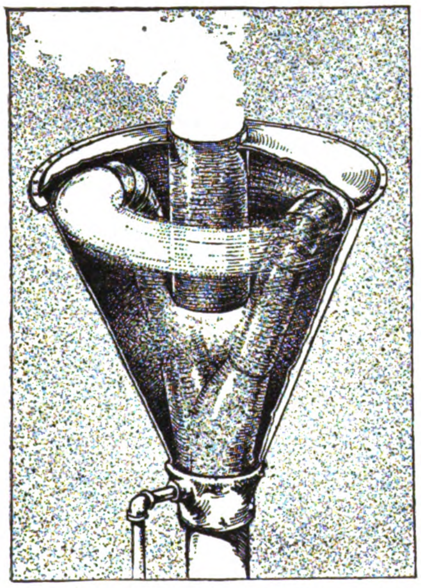


FIG. 4.—STURTEVANT EXHAUST HEAD.

GARL DESK TELEPHONE SET FOR LONG-DISTANCE SERVICE.

Fig. 5 illustrates a desk telephone set manufactured by the Garl Electric Company, Akron, Ohio, for bridging and metallic circuit long distance lines. The set is designed, as intimated, for exchange work and on long-distance circuits, such as toll and bridging lines. The transmitter is of the solid back granular carbon type, and the receiver is double-pole. All contacts and springs are of German silver and all connections thoroughly soldered. The base can be finished in any wood to match the desk, and each outfit has a connecting cord and block and is furnished with either bridged or series signalling apparatus.

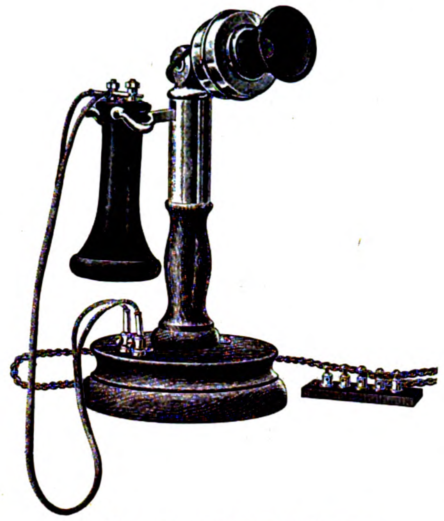


FIG. 5.—LONG-DISTANCE OUTFIT.

HYLO DOUBLE-SERVICE INCANDESCENT LAMP.

Numerous methods have been devised for the purpose of "turning down" an incandescent lamp for sickroom or all-night service. The latest of these is incorporated in the Hylo baby-filament lamp, made by the Phelps Manufacturing Company, Elmwood, Ill. The lamp has two filaments, a large one like that of an ordinary lamp, giving 16 candle-power, and a baby filament, giving one candle-power. The base is so made that when the lamp is screwed home in the socket the large filament is in circuit; unscrewing the lamp slightly cuts out the large filament and puts the small one in circuit. The advantage of such an arrangement is obvious without further comment. The large filament is said to give an average life of 800 hours, and the baby filament an average life of 300 hours. The lamps are also furnished with a baby filament of two candle-power when desired. The lamp is supplied with a base to fit any standard socket. Fig. 6 shows the lamp with the large filament in use, and Fig. 7 represents the baby filament alight.

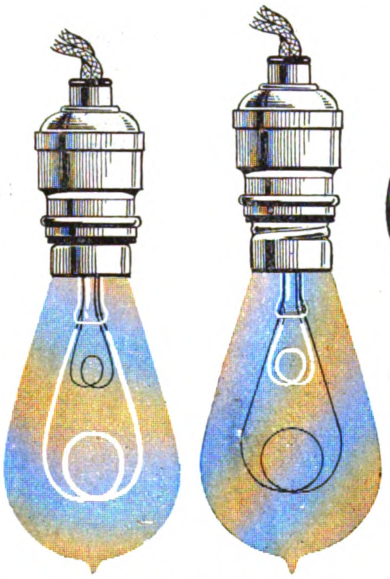


FIG. 6.—HYLO LAMP.—FIG. 7.

STERLING ENCLOSED MOTOR.

One of the most remarkable business policies that has been made public for a long time is that of the Sterling Electric Motor Company, of Dayton, Ohio, which consists, briefly, in manufacturing only one size of motor and building machines of that size in large quantities, making every part rigidly by gauge so that all parts are interchangeable and require no fitting. Fig. 8 illustrates one of these motors, which, as the engraving shows, is of a very compact and attractive form. The magnetic yoke forms the outer casing of the motor, and the upper part of the circle forms one of the pole-pieces. There is only one physical magnet pole, and this one stands vertically below the armature and carries the single field coil. Although only one size of the frame is built, this is provided with different windings to suit various requirements, so that there is quite a range in the actual output of the machine. The windings are designed for different armature speeds, ranging from 300 r.p.m. to 2000 r.p.m., and for any of the three standard direct-current voltages. At 300 r.p.m. the machine develops one-eighth horse-power, and at 2000 r.p.m. one horse-power; at 1200 r.p.m the output is one-half horse-power. These little machines are also furnished for use as dynamos, one winding being for plating service and three others giving the machine capacities of 10, 15 and 20 incandescent lamps, respectively, at speeds of 1200, 1650 and 2100 r.p.m., respectively. The armature conductor is wound directly in the slots of the core by a special machine, and the winding is confined in the slots by strips of bamboo, no binding-wires being used.

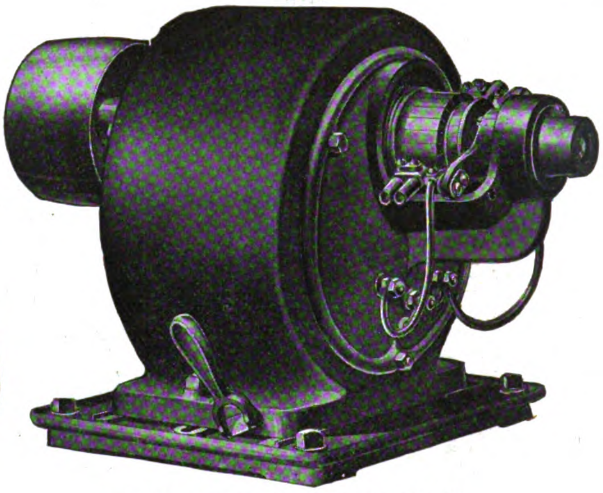


FIG. 8.—STERLING ENCLOSED MOTOR.

THE HYDROMETER SYRINGE.

The specific gravity of the acid of a storage battery plays an important part in its efficient working and frequent tests are necessary to determine its condition. Before the containing jars of the cells were reduced to the small compass necessary in an automobile it was necessary to have a hydrometer floating in the solution where there was plenty of room for its free adjustment to the variation in strength of the electrolyte, and an easy reading could be made. That this is impossible in the tightly-built automobile cells is apparent, and to overcome this difficulty the hydrometer syringe here illustrated was designed. By slightly compressing the bulb and inserting the slender tube through the vent hole in the cover of the cell sufficient acid may be drawn up to float the hydrometer within the large glass tube, and the reading can be made at once. The acid is returned to the cell by again compressing the bulb, and the reading of the next cell is taken. The laborious and uncleanly method of drawing out sufficient acid by a syringe is avoided. The hydrometer syringe is manufactured by The Storage Battery Supply Company, New York.

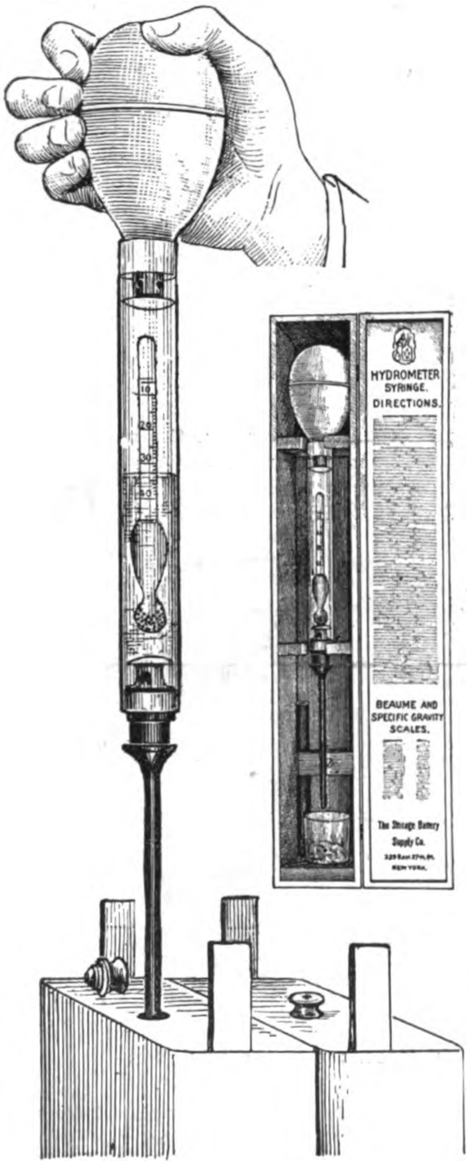

HYDROMETER SYRINGE.
DIRECTIONS.
BEAUME AND SPECIFIC GRAVITY SCALES.
The Storage Battery Supply Co.

FIG. 9.—HYDROMETER SYRINGE.

GREENFIELD VERTICAL ENGINE.

The latest type of vertical automatic engine built by the Greenfield Steam Engine Works, of Harrison, N. J., is shown by Figs. 10 and 11. The engine is built on the same general plan as the throttling engine which the company has been manufacturing successfully for many years. The steam joints are scraped and ground to a perfect fit; the piston is equipped with spring rings; the crosshead has adjustable composition gibs to take up wear; the shaft, piston rod, valve rod and crosshead pin are made of forged steel; the crank-pin box is lined with the best babbitt metal. The bearings are all extra large and long, and adjustments are provided to take up wear; they are self-oiling with chain feed. The governor is of the ordinary fly-wheel type, as shown by the illustration. The speed at which the engine is to run may be adjusted or the direction of rotation changed in a few minutes without removing the governor from the shaft. The speed is altered by bringing the connection of the springs to the centrifugal weights nearer the shaft, adjustment being secured by graduations along the sides of the slots in the weights. All parts of the engine are interchangeable and are easy of access for adjustment or repairs. The engine is quiet running and governs well, making it especially adapted to isolated plants where floor space is an object. Fig. 11 shows a 12-h.p. Greenfield engine direct connected to a Westinghouse dynamo. These engines are built in thirteen sizes ranging from 8 horse-power to 100 horse-power.

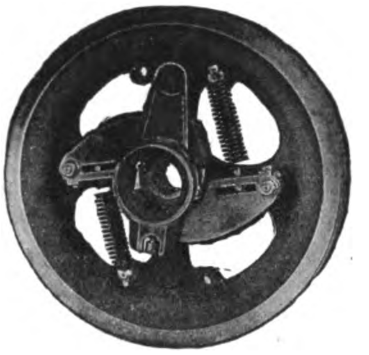


FIG. 10.—GREENFIELD GOVERNOR.

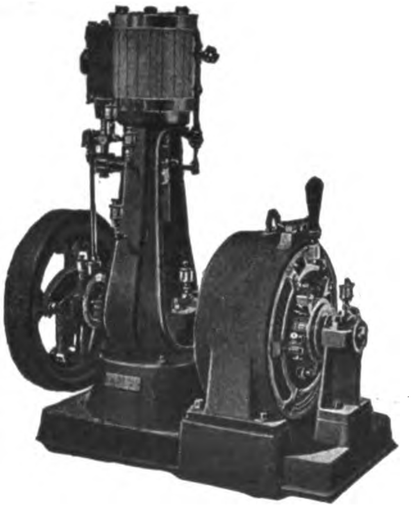


FIG. 11.—GREENFIELD ENGINE.

SPARKER MEDICAL BATTERY.

Kendrick & Davis, of Lebanon, N. H., have put on the market the Sparker medical battery, illustrated by Fig. 12. A dry cell is employed, which is strapped to the base, as shown in the illustration, so that the entire apparatus is self-contained and extremely compact. The coil is a reactive coil of the ordinary type, the strength of which is regulated by means of a metal tube, C, which forms a closed secondary for the winding of the coil. All of the metal parts are nickel-plated, and while the outfit is inexpensive the workmanship is of a high-grade character, so that there is no more liability to disarrangement than in the more expensive medical outfits usually supplied.

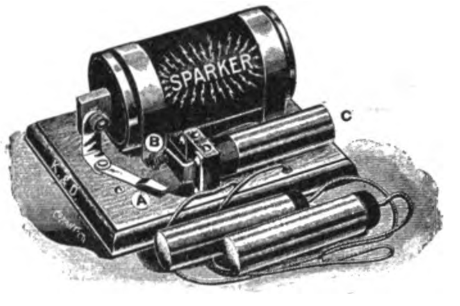
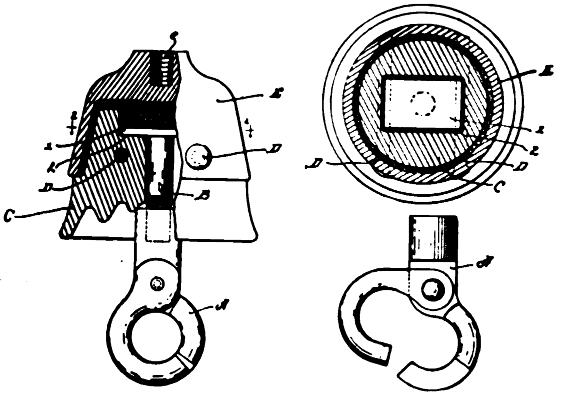


FIG. 12.—MEDICAL COIL AND BATTERY.

A NEW CUTTER ARC LAMP HANGER.

A new form of arc lamp hanger which has been built by the George Cutter Company, of Chicago, is illustrated by Figs. 13 and 14. The lamp is supported by a split ring, A. The lamp is engaged by swinging the pivoted half of the ring upwardly and passing the fixed portion through the eye in the lamp, then closing the pivoted ring-section downward and into position, as shown in Fig. 13. The hook, A, is supported by a bolt, B, to which the hook is threaded. The bolt, B, is in turn supported by an insulator, C, the bolt being provided with a head, 1, and the insulator with a flat supporting portion, 2, upon which the head can rest. The hole in the insulator, C, through which the bolt, B, passes, is made a little larger than the bolt, to prevent cracking and binding. The supporting surface, 2, of the insulator forms the floor of a recess or socket, which is made to correspond with the shape of the head of the bolt so as to prevent the latter from turning and thereby allow the lamp-holding hook or ring, A, to be readily screwed on or off from the bolt.



FIGS. 13 AND 14.—ARC LAMP HANGER.

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